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Volume Nine Number Two

SCHOOL OF MINES

AND

METALLURGY

UNIVERSITY OF MISSOURI

BULLETIN

MARCH, 1917

1916—CATALOGUE—1917

ROLLA, MISSOURI

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SCHOOL OF MINES

AND

METALLURGY

UNIVERSITY OF MISSOURI

FORTY-SIXTH ANNUAL CATALOGUE

ROLLA, MISSOURI

1917

SOUTH GATE—CAMPUS VIEW.

CALENDAR FOR 1917-1918

1917

JANUARY

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FEBRUARY

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1918

JANUARY

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MARCH

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SEPTEMBER

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OCTOBER

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DECEMBER

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ROLLA BUILDING

TABLE OF CONTENTS

	Page
Calendar	4
Board of Curators	5
Executive Committee	6
Faculty	7
History	14
Finances and Endowment	15
Location	18
Buildings	19
Library	22
Admission of Students	23
Curricula	33
Degrees	37
Chemical Engineering	53
Chemistry	53
Civil Engineering	67
Electrical Engineering	126
English and Modern Foreign Languages	76
Geology and Mineralogy	81
Mathematics	89
Mechanical Engineering	95
Metallurgy and Ore Dressing	104
Mining	119
Physics	126
Shop Practice and Drawing	95
Physical Training	132
Excursions	133
General Information	135
Expenses	140
Experiment Station	145
Bureau of Geology and Mines	146
Students Enrolled	152

CALENDAR

1917

May 25, Friday.....Annual Commencement.
May 29, Tuesday at 4 p. m.....Session Ends.
September 7 and 8, Friday and Saturday.....Entrance Examinations.
September 10, Monday.....Registration for First Semester.
September 11, Tuesday.....First Semester Class Work Begins.
November 29, Thursday.....Thanksgiving Holiday.
December 21, Friday, at 4 p. m..Christmas Recess Begins.

1918

January 2, Wednesday, 8 a. m...Christmas Recess Ends.
January 18, Friday.....First Semester Ends.
January 19, Saturday.....Registration for Second Semester.
January 21, Monday.....Second Semester Class Work Begins.
February 22, Friday.....Holiday.
May 24, Friday.....Annual Commencement.

BOARD OF CURATORS

S. L. Baysinger ..... *Rolla, Mo.*
John H. Bradley ..... *Kennett, Mo.*
D. R. Francis ..... *St. Louis, Mo.*
H. B. McDaniel ..... *Springfield, Mo.*
G. E. Muns ..... *Montgomery City, Mo.*
Albert D. Nortoni ..... *St. Louis, Mo.*
C. B. Rollins ..... *Columbia, Mo.*
Sam Sparrow ..... *Kansas City, Mo.*
Milton Tootle ..... *St. Joseph, Mo.*

OFFICERS OF THE BOARD

D. R. Francis ..... *President.*
C. B. Rollins ..... *Vice-President.*
J. G. Babb ..... *Secretary.*
R. B. Price ..... *Treasurer.*

EXECUTIVE COMMITTEE OF THE SCHOOL OF MINES AND METALLURGY

S. L. Baysinger ..... *Rolla.*
Albert D. Nortoni ..... *St. Louis.*
H. B. McDaniel ..... *Springfield.*

OFFICERS OF THE COMMITTEE

S. L. Baysinger ..... *Chairman.*
Edw. Kahlbaum ..... *Secretary.*
C. M. Knapp ..... *Treasurer.*

FACULTY

ALBERT ROSS HILL,
President of the University.
A. B., Dalhousie University, 1892; Ph. D., Cornell University, 1895; LL. D., University of South Carolina, 1905; Dalhousie University, 1908; Westminster College, 1909; Washington University, 1915; Lafayette College, 1915; Universities of Colorado and Michigan, 1916.

AUSTIN LEE McRAE,
Director and Professor of Physics.
B. S., University of Georgia, 1881; S. D., Harvard University, 1886.

JOSEPH WAYNE BARLEY,
Professor of English and Modern Languages.
A. B., 1897; A. M., 1905; William Jewell College; Ph. D., University of Pennsylvania, 1911.

GUY HENRY COX,
Professor of Geology and Mineralogy.
B. S. in General Science, Northwestern University, 1905; M. A., University of Wisconsin, 1908; Ph. D., University of Wisconsin, 1911; E. M., School of Mines, 1914. On leave 1916-17.

GEORGE REINALD DEAN,
Professor of Mathematics.
C. E., School of Mines, 1890; B. S. in Mathematics and Physics, School of Mines, 1891.

HAROLD SHIELDS DICKERSON,
Professor of Mechanical Engineering.
B. S., University of Michigan, 1905; B. S., Purdue University; M. E., Purdue University, 1911.

CARROLL RALPH FORBES,
Professor of Mining and Secretary of the Faculty.
B. S., Michigan College of Mines, 1902; E. M., Michigan College of Mines, 1903.

VICTOR HUGO GOTTSCHALK,
Professor of Chemistry.
B. S. in Chemistry and Metallurgy, School of Mines. 1898; M. S., School of Mines, 1900. On leave 1916-17.

ELMO GOLIGHTLY HARRIS,
Professor of Civil Engineering.
C. E., University of Virginia, 1882.

HAROLD LESLIE WHEELER,
Librarian.
A. B., Brown University, 1910; B. L. S., New York State Library School, 1913.

FRANK EDWARD DENNIE,
Associate Professor of Athletics and Physical Director.
B. S. in Civil Engineering, Brown University, 1909.

LEON ELLIS GARRETT,
Associate Professor of Mathematics.
B. S. in General Science, School of Mines, 1901.

HORACE THARP MANN,
Associate Professor of Metallurgy and Ore Dressing, in charge of Metallurgy Department.
B. S. in Mining Engineering, School of Mines, 1908; M. S. in General Science, School of Mines, 1909; E. M., School of Mines, 1910.

JOSEPH HENRY BOWEN,
Assistant Professor of Shop Work and Drawing.
Graduate, Miller School, Virginia.

CHARLES YANCEY CLAYTON,
Assistant Professor of Ore Dressing and Metallurgy.
B. S. in Metallurgy, School of Mines, 1913; Met. E., School of Mines, 1916.

CHARLES LAURENCE DAKE,
Assistant Professor of Geology and Mineralogy, in charge of Geology Department.
A. B., 1911; A. M., 1912; University of Wisconsin.

FRANCIS POTTER DANIELS,
Assistant Professor of Modern Languages.
A. B., University of Michigan, 1895; A. M., University of Missouri, 1897; Ph. D., University of Missouri, 1906.

LESTER DAVISSON HAMMOND,
Acting Assistant Professor of Chemistry.
A. B., University of Indiana, 1907; A. M., University of Wisconsin, 1910; Ph. D., University of Wisconsin, 1916.

JOHN CHARAVELLE INGRAM,
Assistant Professor of Chemistry, in charge of Chemistry Department.
B. S. in General Science, School of Mines, 1913.

EDGAR SCOTT McCANDLISS,
Assistant Professor of Civil Engineering.
B. S. in Civil Engineering, Purdue University, 1909.

HARRY ATWOOD AMBLER,
Instructor in Chemistry.

RALPH EARL DUFFY,
Instructor in Drawing.
B. S. in E. E., University of Missouri, 1908.

FLOYD HILL FRAME,
Instructor in Physics and Electricity.
A. B., Clark College, 1912.

VAN BUREN HINSCH,
Instructor in Mathematics.
B. S., School of Mines, 1909.

NEIL CHARLES HUTSINPILLAR,
Instructor in English.
B. A., Ohio State University, 1908.

DONALD CAMPBELL KEMP,
Instructor in Geology and Mineralogy.
A. B., University of Colorado, 1915.

*R. STEWART LILLARD,
Instructor in Civil Engineering.
B. S. in C. E., University of Tennessee, 1916.

GARRETT A. MUILENBURG,
Instructor in Geology and Mineralogy.
A. B., University of Iowa, 1912; M. S., University of Iowa, 1913.

†WILLIAM HARRY RISHER,
Instructor in Mining and Surveying.
B. S. in C. E., Purdue University, 1912.

MARTIN HARMON THORNBERRY,
Research Assistant.
B. S., School of Mines, 1912.

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*Elected January 1, 1917.
†Resigned December 10, 1916.

STUDENT ASSISTANTS

EVAN EARL ASHLOCK,
Student Assistant in Drawing.

CLARENCE EDWARD BARDSLEY,
Student Assistant in Surveying and Drawing.

JOSEPH C. BARTON,
Student Assistant in Mining.

JAMES HENRY BOCK, JR.,
Student Assistant in Geology and Mineralogy.

JOHN STAFFORD BROWN,
Student Assistant in Geology and Mineralogy.

ROBERT BRUCE,
Student Assistant in Gymnasium.

*VICTOR HUGO DOELING,
Student Assistant in Ore Dressing and Metallurgy.

†HOWARD ANDREW HORNER,
Student Assistant in Ore Dressing and Metallurgy.

*JOHN LOGAN IMLAY,
Student Assistant in Gymnasium.

*WILLIAM HENRY KAMP,
Student Assistant in Gymnasium.

FREDERICK ROBERT LANG,
Student Assistant in Chemistry.

†MAURICE CECIL LUCKY,
Student Assistant in Geology and Mineralogy.

EARLE NELSON MURPHY,
Student Assistant in Gymnasium.

JAMES RAYMOND NEVIN,
Student Assistant in Gymnasium.

BENJAMIN GUTHRIE NICHOLS,
Student Assistant in Chemistry.

*First semester.
†Second semester.

JAMES WILLARD PUGH,
Student Assistant in Ore Dressing and Metallurgy.

JOHN JOSHUA SHIPLEY,
Student Assistant in Drawing and Physics.

RAY OTTO SHRIVER,
Student Assistant in Civil Engineering.

†LESLIE CARLISLE SKEEN,
Student Assistant in Civil Engineering.

†OSCAR ELI STONER,
Student Assistant in Mining.

MARK LOREN TERRY,
Student Assistant in Chemistry.

THOMAS PATRICK FRANCIS WALSH,
Student Assistant in English.

*WALTER CHARLES ZEUCH,
Student Assistant in Physics.

LAWRENCE JOSEPH ZOLLER,
Student Assistant in Drawing and English.

OTHER OFFICERS

ROBERT RICHMOND DICKERSON,
Superintendent of Buildings and Grounds.

EDW. KAHLBAUM,
Registrar.

ZELLA ELIAS,
Stenographer.

MABEL HAWKINS,
Stenographer.

*First semester.
†Second semester.

FACULTY COMMITTEES

Admission and Advanced Standing.
Dean, Barley and Ingram.

Alumni Exchange.
Mann, Clayton, Dean, Garrett and Ingram.

Athletics.
McCandliss, Barley, Bowen, Clayton and Forbes.

Buildings and Grounds.
Harris, Dickerson, Duffy and McCandliss.

Curricula and Degrees.
Forbes, Dickerson, McCandliss, Mann and Muilenburg.

Examination and Schedule.
Dake, Clayton, Duffy and Frame.

Publications.
Barley, Daniels and Wheeler.

Student Council.
Garrett, Dennie, Forbes, Mann and Risher.

Theses.
Harris, Dake, Forbes, Ingram and Mann.

SPECIAL LECTURES

Bishop T. P. Thurston, D. D., Muskogee, Oklahoma.
"A Life Investment."
October 15, 1916.

H. A. Buehler, State Geologist, Rolla, Missouri.
"Arizona Meeting, A. I. M. E."
November 9, 1916.

B. O. Taylor, Kansas City, Missouri.
"Character Judging."
November 20, 1916.

Dr. Harry R. McKeen, Little Rock, Ark.
"Commercial Preparedness."
November 27, 1916.

James C. Long, St. Louis, Missouri. Of SKF Ball Bearing Co.,
"Ball Bearings and their Applications."
December 5, 1916.

H. J. Hirshman, St. Louis, Missouri. Of the National Tube Co.
"From the Iron Ore to the Finished Boiler Tubes," moving pictures.
December 7, 1916.

Luman Post, M. D., St. Louis, Missouri.
"The Prevention of Blindness."
December 19, 1916.

Byron L. Ashdown, B. S., New York City.
"Canal Digging."
January 5, 1917.

Lewis A. Delano, E. M., Bonne Terre, Missouri.
"Influence of Ball Mills on the Milling Practice in Southeast Missouri."
February 14, 1917.

Theodore S. Dunn, E. M., Pittsburg, Pa.
"Workmen's Compensation Insurance."
February 23, 26, 1917.

Henry M. Payne, E. M., New York City.
"Gold Dredging in Frozen Gravel."
February 28, 1917.

M. O. Baxter, Bartlesville, Okla.
"The Doherty School of Gas Engineering."
March 14, 1917.

HISTORY OF THE SCHOOL

In 1870 the General Assembly of Missouri, in accepting the donation of land for educational purposes made by the General Government through an Act of Congress, approved July 2, 1862, established an Agricultural and Mechanical College and a School of Mines and Metallurgy. The design of these institutions is set forth in the following language:

Object of These Colleges.—The leading objects of said colleges shall be to teach such branches as are related to agriculture and mechanic arts and mining, including military tactics, and without excluding other scientific and classical studies, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life. (Laws 1915, Sec. 11134.)

Right to Confer Degrees.—The college of agriculture and the school of mines and metallurgy shall have power to confer degrees suitable to their designs and courses of study; and the school of mines and metallurgy shall provide courses for, and shall confer the bachelor of science and professional degrees in mining engineering, in metallurgy, in mechanical engineering, in electrical engineering, in chemical engineering, in civil engineering and the degrees of bachelor and master of science in general science. (Laws 1915, Sec. 11141.)

The School of Mines and Metallurgy was located at Rolla, Phelps County. Here, in November, 1871, the school was formally opened. The statutes fix the status of the school as one of the Colleges of the State University. Its affairs are under the immediate supervision of an Executive Committee, consisting of three members of the University Board of Curators, selected by that body. The need of general culture as a foundation and accompaniment of specifically technical training led to the establishment, in 1885, of an Academic Course in compliance with the following act of the General Assembly:

"Academic Course of Study, Etc.—That the obligation of the State to the General Government, assumed by the acceptance of the land grant of July 2, 1862, may be more fully discharged, and in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life, the Board of Curators of the University of the State of Missouri shall prescribe and adopt a liberal academic course of study to be taught in the School of Mines and Metallurgy located at Rolla, in addition to the courses now taught in said school, and may confer the degree of bachelor of science upon all students who shall complete said course in said school to the satisfaction of the faculty thereof." (Revised Statutes, 1909, Section 11135.)

ENDOWMENT

The proceeds from the sale of 275,000 acres of public lands granted to Missouri by the General Government amount to about $350,000, which is invested in State certificates of indebtedness bearing 5 per cent interest. The School of Mines receives one-fourth of the yearly income thus accruing.

"The proceeds of the sale of lands donated to the State of Missouri by the United States for the support of the College of Agriculture and Mechanic Arts and the School of Mines and Metallurgy, by Act of Congress, approved July 2, 1862, represented by State certificates of indebtedness, of the following amounts and dates:

July 2, 1883	$242,000.00
November 1, 1883	5,000.00
January 29, 1884	5,000.00
April 19, 1884	35,000.00
April 2, 1885	5,000.00
February 25, 1886	5,000.00
January 1, 1888	5,000.00
December 15, 1888	5,000.00
May 15, 1889	5,000.00
July 1, 1891	5,000.00
May 15, 1893	5,000.00
July 1, 1895	22,881.19
April 9, 1895	5,000.00
Representing a total of	$349,881.19

Now issued or any certificates which may hereafter be issued under any general or special act of the General Assembly; one-fourth of the interest of these funds shall be paid to the Treasurer of the School of Mines and Metallurgy, at Rolla, for the maintenance of said institution."

"The proceeds of sales of lands donated to the School of Mines and Metallurgy, at Rolla, represented by the State certificate of indebtedness of $2,000, dated April 15, 1893, issued under act of March 31, 1883, interest on which shall be applied to the maintenance of the School of Mines and Metallurgy, at Rolla."

"The State certificate of indebtedness of $3,000, issued under act of April 1, 1895, dated April 1, 1896, four-fifths of the interest to be applied to the maintenance of the State University, at Columbia, and one-fifth to the School of Mines and Metallurgy, at Rolla,

and also any other certificate which may hereafter be issued and held in trust for this fund under any general or special act of the General Assembly." (Revised Statutes, 1909, Section 11161.)

In addition to the foregoing, the School of Mines receives one-fourth of the interest on municipal and drainage district bonds amounting to $16,000.00, purchased under authority of Section 11168 of the Revised Statutes of 1909, amended by act approved April 7, 1911, Session Acts, 1911, p. 415.

By an Act of Congress, approved August 30, 1890, commonly known as the "Morrill Bill," the General Government assists each State and Territory in maintaining a college or colleges in accordance with the act of July 2, 1862. After deducting one-sixteenth for the Lincoln Institute, Missouri gives one-fourth of the remainder of this fund to the School of Mines.

"All sums collected under the provisions of an Act of Congress, approved August 30, 1890, commonly known as the 'Morrill Bill,' shall be paid as follows: One-sixteenth thereof for the benefit of the Lincoln Institute and one-fourth of the remainder to the Treasurer of the School of Mines, at Rolla, Missouri." (Revised Statutes, 1909, Section 11171.)

In 1891 the Government returned to the various States the sums collected from their citizens by the imposition during the Civil War of a "direct tax." The amount thus refunded to Missouri was $646,958.23, and the Thirty-sixth General Assembly of the State won the gratitude of the friends of higher education by establishing this as a permanent endowment for the State University at Columbia and the School of Mines and Metallurgy at Rolla. One-fifth of the income from this endowment is received by the School of Mines.

"The State certificate of indebtedness of $646,958.23, derived from 'direct tax' received from the United States, dated April 1, 1891, issued under act of March 26, 1891, four-fifths of the interest to be applied for the maintenance of the State University, at Columbia, and one-fifth for the School of Mines and Metallurgy, at Rolla." (Revised Statutes, 1909, Section 11161.)

The Fortieth General Assembly of the State passed an act providing for a tax on collateral inheritances for the benefit of the State University, and the Forty-first General Assembly provided that one-fifth of the funds derived from this tax shall be appropriated for the benefit of the School of Mines.

Collateral Inheritance Tax.—"The moneys received by the State Treasurer under the provisions of this article shall be deposited in the State Treasury to the credit of the fund now existing in the State Treasury, and known as the 'State Seminary Moneys,' for the maintenance, support and better equipment of the buildings, apparatus, books, instruction, etc., of the University of the State of

Missouri, to an amount not exceeding in any one year the equivalent of one-tenth of one mill for every dollar of the assessed valuation of taxable property of the State for the said year: *Provided*, that one-fifth of all such moneys so received shall be devoted to the use of the School of Mines and Metallurgy, a department of the said University." (Revised Statutes, 1909, Section 312.)

LOCATION

The School of Mines is located at Rolla, the county seat of Phelps County, on the St. Louis and San Francisco Railroad, approximately halfway between St. Louis and Springfield.

Rolla is on the crest of the Ozark uplift, at an elevation of eleven hundred forty feet above the sea level, and has an agreeable and notably healthful climate. Its position on the great transcontinental railway system makes it readily accessible.

The school is within easy reach of the important mining districts of the State, which offer splendid facilities for the study of mining geology, mining methods, ore dressing, and mining machinery. Numerous recent improvements, due to the systematic study of Missouri ore deposits, methods of ore treatment, and the extensive development of low-grade lead and zinc ores, have given the school advantages for the application of the theories of geology, mining, and ore dressing to practice.

The smelting industry of the State is very important, and every courtesy is extended to the professors and students of the school during their visits to these metallurgical plants. The methods of mining coal and clay can be readily studied in Missouri and the adjoining fields. Numerous clay-working and cement plants in St. Louis and vicinity offer good opportunity for the study of these important industries. In and about St. Louis are also various chemical plants which are visited from time to time.

CAMPUS AND ATHLETIC FIELD

The grounds of the School of Mines are situated in the highest part of the City of Rolla, and are over twenty-seven acres in extent. The campus contains beautiful lawns, groves of native oak, and maple shade trees.

The Jackling Field has a good baseball diamond, a football gridiron, tennis courts, and a 440-yard running track.

The new gymnasium is conveniently situated at the east end of the athletic field and is equipped with lockers, shower baths, dressing rooms, swimming pool and the usual gymnastic apparatus.

BUILDINGS

Rolla Building.

This building was originally built by the City of Rolla as a High School building, but was sold to the State in 1871, and for many years was the principal building of the School of Mines and Metallurgy. It is a brick structure, ninety feet by sixty feet, four stories high, including a working basement. It contains the library, laboratories, drafting rooms, offices, and geological collections of the State Geological Survey, toilet, shower baths, and locker rooms.

Chemical Hall.

The main portion of this building was erected in 1885 and two wings were added in 1902. The main building is two stories high and one hundred two feet in length by fifty-five feet in width. Each wing is fifty-five feet by sixty feet and one story high. A stock room twenty-eight feet wide by forty-four feet long, two stories high, was erected in 1915, and is accessible to the qualitative and quantitative laboratories. This entire building, including a large basement, is used for chemistry.

Mining Building and Power Plant.

This building, erected in 1895, is a tile-roof, press-brick structure, and consists of two distinct portions, one containing offices, an instrument room, and laboratories—the other comprising a large mining laboratory, an engine room, and a boiler room.

Mechanical Hall.

This two-story brick building, erected in 1901, is one hundred fifty feet by sixty feet and was specially designed for mechanical work. The second floor includes a demonstration lecture room, a shop for bench work in wood, and a temporary gymnasium. The first floor contains a lathe room for wood turning, a forge room, a metal-working room, and a stock and tool room.

Each floor is provided with a lavatory and lockers, and an office for the instructor.

Norwood Hall.

The corner stone of this building was laid November 23, 1902, and the building was first used in 1903. It contains adequate quarters for lecture and recitation rooms for physics, geology, mineralogy, civil engineering, English, mathematics; also drawing rooms and laboratories for physics, geology, mineralogy and civil engineering.

Ore Dressing Building.

This is a three-story gray press-brick building with a basement and two large one-story wings. Two stories and the west wing has been in use since January, 1908, and the east wing was erected in 1909. The building provides quarters for metallurgy and ore dressing. The building was completed in 1911 and contains over twenty-five thousand square feet of floor space.

Parker Hall.

This is a fireproof, two-story gray press-brick building, with a well-lighted basement. The main portion of the building is one hundred two by fifty-five feet and the wing is fifty-eight by sixty feet. The library occupies the second story of the building; the administrative offices, faculty room, and board room are located on the first floor; and the assembly room is in the two-story wing. This building was erected in 1912.

The Gymnasium.

This building, which was completed in 1915, was made possible by the appropriation of seventy thousand dollars by the Forty-seventh General Assembly. The Gymnasium is located at the north end of the campus, in a portion of Main street which was vacated by the city of Rolla for the purpose. The front is to the south, and the west side opens onto Jackling Field.

The building occupies a space seventy-two feet wide and one hundred twenty-seven feet long, and is finished in dark red rough brick with gray terra-cotta trimmings. The interior is of fireproof construction, with concrete and composition floors, except in the gymnasium proper, which is floored with maple. Tile partitions are used throughout the building, and the roof is concrete, supported by steel trusses and covered with asbestos roofing.

On the ground floor, entered by the main entrance on the south of the building, are the cloakrooms, locker rooms, training quarters and visiting teams' room, shower baths and swimming pool. The

swimming pool is twenty by sixty feet, finished in white enamel and equipped with all modern appliances. The water supplied to the pool is circulated with a small motor-driven pump, and a constant temperature is maintained by passing the water through a special steam boiler.

The mezzanine floor is on a level with Jackling Athletic Field, and opens upon a terrace which parallels the running track. On this floor are committee rooms, general toilet rooms, the auxiliary gymnasium and balcony overhanging the swimming pool. On the second floor is the gymnasium room proper. This room is seventy feet wide by ninety feet long and is well equipped. On this floor also is the examination room, office and reception room.

The gallery of the gymnasium is a running track, with twenty-six laps to the mile. At the south end of the building on the third floor is a large lounging and rest room.

Carpenter Shop.

The general repair work of the school and construction of laboratory equipment is carried on in a frame building, one hundred fifty feet by twenty-two feet. This building is located west of Mechanical Hall, and includes a store room for lumber.

LIBRARY

HAROLD L. WHEELER, Librarian; MISS WESTLAKE, MR. COOPER, MR. SCHIERMEYER, MR. TIDD.

The library has been completely reorganized and catalogued and now occupies the second floor of Parker Hall. The new quarters consist of a large, well-lighted reading room, a stack room, equipped with a double-deck Snead stack, capacity 45,000 volumes, and adequate workrooms for the library staff. All equipment is new and up-to-date, meeting in every way the needs of the library and its clientele.

The collection of books now numbers 20,000 carefully selected volumes, together with a large collection of pamphlets, bulletins and reports of mining companies. The bulk of the collection consists of works in the sciences, chiefly geology, physics, chemistry, and the useful arts, the main part of this division being engineering and mining treatises. Besides these collections, the library has the representative works in American and English literature, some fiction, a good section of biography, and the latest books of description and travel, this latter division being kept especially strong, so that the students may keep informed concerning the manners and customs of the people and the characteristics of the countries into which they are likely to go to follow their vocation.

The library is a subscriber to the leading technical periodicals and the publications and transactions of societies and congresses. The leading general magazines are taken for recreational reading. The contents of the back files of this material is made available through the general periodical indexes and the engineering and mining indexes.

The Dewey decimal system of classification is used and the resources of the collection are made available through a full dictionary catalogue of authors, titles, and subjects.

Interlibrary loan arrangements exist between this library and the Library of Congress, the St. Louis Public Library, John Crerar Library of Chicago, and the University Library at Columbia. By this arrangement books not in the collection at the School of Mines may be borrowed for the use of the students for a limited time.

During the past year the librarian has given lectures and instruction to the freshman and senior classes on the library methods employed and the use of the library.

The reading room is open daily from 7.45 to 12; 1 to 6, and 7 to 10; Sunday 2 to 5. Books and periodicals may be borrowed by all officers and students of the school, and by others having special permission.

READING ROOM, LIBRARY.

PARKER HALL

ADMISSION

Under the statutes, persons of either sex, sixteen years of age or over, whether residents of Missouri or not, may be admitted upon evidence of sufficient preparation. Students should have a good, liberal education, its elements at least, before beginning technical study. The average age of members of the present Freshman class at entrance was about eighteen years. Specific requirements have been fixed by consideration of the express design of the school—"to promote the education of the industrial classes" in certain branches of engineering—and of the educational opportunities of its intended beneficiaries.

Students are admitted in the following ways:

By Certificate:

Applicants who are graduates from fully accredited high schools will be admitted without examination, provided they present a certificate signed by the superintendent or principal showing that the applicant has to his credit fifteen units. Of these units three in English, one and one-half in Algebra, one in Plane Geometry are required.

Graduates of fully accredited high schools who lack credit in the required units must pass an examination to make up such deficiency.

Graduates of partially accredited high schools must pass examination in all of the units in which they are deficient.

By Examination:

Applicants who are not graduates of approved high schools are required to pass examinations in fifteen units as outlined below, a unit being equivalent to a year's work in one subject as given in approved high schools. Conditions may be allowed in two of the fifteen units, but these must be removed within one year from the date of entrance.

Applicants from accredited high schools who are not graduates will not be permitted to enter if they receive conditions in any subject or subjects unless a year or more has elapsed since they attended the high school.

By Advanced Standing:

Applicants may be admitted to advanced standing either upon examination in the subjects of the previous year or years or upon certificate from another institution of work accomplished which, in the estimation of the faculty, is equivalent to that completed here by the class into which entrance is sought. They must also before becoming candidates for degrees present evidence of the satisfactory completion of all entrance requirements into the Freshman class. Every applicant must also present a letter of honorable dismissal from the school last attended. Applicants for advanced standing should communicate with the Director as early as possible, and all claims for advanced standing, in order to receive recognition, must be made by the students within one semester after entrance.

As Special Students:

Special students may be admitted without passing the entrance examination under the following provisions:

1. They must be at least twenty-one years of age.
2. They must show good reasons for not taking a regular course.
3. They must pass such examinations or other tests as shall demonstrate their fitness to pursue profitably all the subjects selected by them.
4. They shall not be candidates for a degree.
5. Special students are expected to do particularly good work in the subjects which they choose. If at any period of the session their work becomes unsatisfactory, their connection with the school will be severed. When the work is chiefly of a laboratory nature, they will be required to take at the same time as much classroom work as the faculty may designate for each particular class.

Definition of Entrance Units

ENGLISH. (4 Units.)

The four units that may be offered in English include grammar, composition and rhetoric, and literature.

The candidate will be required to show a reasonable proficiency in the principles of English grammar, including sentence-analysis. He will be required to show the ability to express himself coherently and correctly, with a fair mastery of the forms of writing, spelling and punctuation, sentence and paragraph structure. He will be examined on the literature listed below, and, if he desires four units, will be required to show also a knowledge of the history of English literature.

The classics prescribed are as follows:

1915—1919

For Reading

GROUP I.—CLASSICS IN TRANSLATION. TWO TO BE SELECTED.—The Old Testament, comprising at least the chief narrative episodes in Genesis, Exodus, Joshua, Judges, Samuel, Kings, and Daniel, together with the books of Ruth and Esther; Homer's Odyssey, with the omission, if desired, of Books I, II, III, IV, V, XV, XVI, XVII; Homer's Iliad, with the omission, if desired, of Books XI, XIII, XIV, XV, XVII, XXI; Virgil's Aeneid. The Odyssey, Iliad, and Aeneid should be read in English translations of recognized literary excellence. For any selection from this group a selection from any other group may be substituted.

GROUP II.—SHAKESPEARE. TWO TO BE SELECTED.—Shakespeare's Midsummer-Night's Dream; Merchant of Venice; As You Like It; Twelfth Night; The Tempest; Romeo and Juliet; King John; Richard II; Richard III; Henry V; Coriolanus; Julius Cæsar; Macbeth; Hamlet.

N. B.—The last three only, if not chosen for study.

GROUP III.—PROSE FICTION. TWO TO BE SELECTED.—Malory's Morte d'Arthur (about 100 pages); Bunyan's Pilgrim's Progress, Part I; Swift's Gulliver's Travels (Voyages to Lilliput and to Brobdingnag); Defoe's Robinson Crusoe, Part I; Goldsmith's Vicar of Wakefield; Frances Burney's Evelina; Scott's Novels, any one; Jane Austen's Novels, any one; *either* Maria Edgeworth's Castle Rackrent, *or* The Absentee; Dickens's Novels, any one; Thackeray's Novels, any one; George Eliot's Novels, any one; Mrs. Gaskell's Cranford; *either* Kingsley's Westward Ho! *or* Hereward the Wake; Reade's The Cloister and the Hearth; Blackmore's Lorna Doone; Hughes' Tom Brown's Schooldays; *either* Stevenson's Treasure Island, *or* Kidnapped, *or* The Master of Ballantrae; Cooper's Novels, any one; Poe's Selected Tales; *either* Hawthorne's The House of the Seven Gables, *or* Twice Told Tales, *or* Mosses from an Old Manse; A collection of short stories by various standard writers.

GROUP IV.—ESSAYS, BIOGRAPHY, ETC. TWO TO BE SELECTED.—*Either* the Sir Roger de Coverley Papers, *or* Selections from The Tatler and The Spectator (about 200 pages); Boswell's Selections from the Life of Johnson (about 200 pages); Franklin's Autobiography; *either* Irving's Selections from the Sketch Book (about 200 pages), *or* The Life of Goldsmith; Southey's Life of Nelson; Lamb's Selections from the Essays of Elia (about 100 pages); Lockhart's Selections from the Life of Scott (about 200 pages); Thackeray's Lectures on Swift, Addison and Steele in the English Humorists; Macaulay: one of the following essays: Lord Clive, Warren Hastings, Milton, Addison, Goldsmith, Frederic the Great, *or* Madame d'Arblay; Trevelyan's Selections

from Life of Macaulay (about 200 pages); *either* Ruskin's Sesame and Lilies, *or* Selections (about 150 pages); Dana's Two Years Before the Mast; Lincoln's Selections, including at least the two Inaugurals, the Speeches in Independence Hall and at Gettysburg, the Last Public Address, *and* Letter to Horace Greeley, together with a brief memoir or estimate of Lincoln; Parkman's The Oregon Trail; Thoreau's Walden; Lowell's Selected Essays (about 150 pages); Holmes's The Autocrat of the Breakfast Table; Stevenson's Inland Voyage, *and* Travels with a Donkey; Huxley's Autobiography *and* selections from Lay Sermons, including the addresses on Improving Natural Knowledge, A Liberal Education, *and* A Piece of Chalk; A collection of Essays by Bacon, Lamb, De Quincey, Hazlitt, Emerson, and later writers; A collection of Letters by various standard writers.

Group V.—Poetry. Two to be Selected.—Palgrave's Golden Treasury (First Series): Books II and III, with special attention to Dryden, Collins, Gray, Cowper, and Burns; Palgrave's Golden Treasury (First Series): Book IV, with special attention to Wordsworth, Keats, and Shelley (if not chosen for study); Goldsmith's The Traveller, and The Deserted Village; Pope's The Rape of the Lock; A Collection of English and Scottish Ballads, as for example, some Robin Hood ballads, The Battle of Otterburn, King Estmere, Young Beichan, Bewick and Grahame, Sir Patrick Spens, and a selection from later ballads; Coleridge's The Ancient Mariner, Cristabel, and Kubla Khan; Byron's Childe Harold, Canto III or IV, and The Prisoner of Chillon; either Scott's The Lady of the Lake or Marmion; Macaulay's The Lays of Ancient Rome, The Battle of Naseby, The Armada, Ivry; either Tennyson's The Princess, or Gareth and Lynette, Lancelot and Elaine, and The Passing of Arthur; Browning's Cavalier Tunes, The Lost Leader, How They Brought the Good News from Ghent to Aix, Home Thoughts from Abroad, Home Thoughts from the Sea, Incident of the French Camp, Herve Riel, Pheidippides, My Last Duchess, Up at a Villa—Down in the City, The Italian in England, The Patriot, "De Gustibus—," The Pied Piper, Istans Tyrannus; Arnold's Sohrab and Rustum, and The Forsaken Merman; Selections from American Poetry, with special attention to Poe, Lowell, Longfellow, and Whittier.

For Study

Group I.—Drama. One to be Selected.—Shakespeare's Julius Caesar, Macbeth, Hamlet.

Group II.—Poetry. One to be Selected.—Milton's L'Allegro, Il Penseroso, and either Comus or Lycidas; Tennyson's The Coming of Arthur, The Holy Grail, and the Passing of Arthur; The selections from Wordsworth, Keats, and Shelley in Book IV of Palgrave's Golden Treasury (First Series).

GROUP III.—ORATORY. ONE TO BE SELECTED.—Burke's Speech on Conciliation with America; Macaulay's Two Speeches on Copyright, and Lincoln's Speech at Cooper Union; Washington's Farewell Address, and Webster's First Bunker Hill Oration.

GROUP IV.—ESSAYS. ONE TO BE SELECTED.—Carlyle's Essay on Burns, with a selection from Burns' Poems; Macaulay's Life of Johnson; Emerson's Essay on Manners.

MATHEMATICS. (4 Units.)

The four units which may be offered in mathematics are as follows:

ALGEBRA. (1½ Units.) Elementary algebra, including the elementary operations, solution of simple and simultaneous linear equations, factoring, radicals, exponents, quadratic equations, equations containing radicals, imaginaries, simultaneous quadratics, higher equations solved as quadratics, relations of roots and coefficients of quadratics and higher numerical equations, solution of higher equations by factoring, Horner's method of approximation, binomial theorem for positive integral exponent, ratio and proportion, and logarithms.

While the study of these particular subjects is recommended, it is not expected that the student shall be able to pass an examination on each and every one of them.

PLANE GEOMETRY (1 Unit.) The work in plane geometry must cover a full year in any good text. It is recommended that considerable attention be paid to the applications of algebra to geometry, and of geometry to algebra and arithmetic.

SOLID GEOMETRY. (½ Unit.) The same recommendations apply here as in plane geometry.

TRIGONOMETRY. (1 Unit.) It is to be understood at the outset that this work will not be accepted for advanced standing. This branch of mathematics is of such great importance to the practical engineer that the whole subject must be reviewed and the student led to a point of view which it is impossible to attain in a high school course.

HISTORY.

Four units may be offered in history; one each in Ancient History, Medieval and Modern History, English History, and American History.

CIVIL GOVERNMENT.

One-half unit may be offered in Civil Government. This is the equivalent of one-half year's work in the fourth year of a high school, and the applicant should have a knowledge of the chief organs of local, state, and national government and a knowledge of the historical development of the government.

Physiography.

A student may offer one unit in physiography. A description of this unit will be sent on request.

PHYSICS.

The two units that may be offered in physics are as follows:

1. A year's work, five periods per week, of which at least two must be double periods in individual laboratory work. At least thirty-five exercises, selected from a list of sixty or more, equivalent to those recommended by the National Educational Association, must be completed.

2. A continuation of the laboratory for another year, or a year's work in a more advanced text together with the laboratory work.

Laboratory notebooks must be presented by those who are required to take the entrance examination.

DRAWING.

Two units may be offered.

MANUAL TRAINING.

Two units in manual training may be offered. One unit should be in Bench Work and one in Mechanical Drawing. The time required in each of these subjects is five double periods for one year or five single periods for two years. Where conditions permit it is generally advisable to give these subjects as parallel courses.

LATIN.

The four units that may be offered in Latin are as follows:

1. Collar and Daniel's First Latin Book, or the equivalent.

2. Three books of Caesar's Gallic War with composition based thereon in Moulton and Collar's Preparatory Latin Composition or in Daniel's New Latin Composition. For one book of the Gallic War the equivalent in time of Viri Romae, Nepos, or Eutropius may be offered.

3. Two additional books of the Gallic War and four Orations of Cicero with compositions based thereon in the books mentioned above.

4. Ovid's Metamorphoses (2,000 lines) and four books of Virgil's Aeneid, with prosody.

GREEK.

The three units that may be offered in Greek are as follows:

1. Ball's Elements of Greek, or White's First Greek Book.

2. Four books of Xenophon's Anabasis, Pearson's Greek Prose Composition, or its equivalent, Goodwin's Greek Grammar.

3. Ten Orations of Lysias and the first four books of Homer's Odyssey, or an equivalent amount of other Greek authors. Bridgman's Parallel Exercises based on Lysias.

GERMAN, FRENCH, SPANISH.

Three units may be offered in German, French, or Spanish. A description of the units will be sent on request. These units will not be accepted for advanced standing.

CHEMISTRY.

The two units that may be offered in chemistry are as follows:

1. A year's work in chemistry, five periods per week, of which at least two must comprise laboratory work.

2. A second year's work in the subject, five periods per week, of which at least two must be laboratory work.

Notebooks showing work done must be presented by those who are required to take the entrance examinations.

These courses will be accepted for admission, but not for advanced standing.

BOOKKEEPING.

One unit may be offered.

COMMERCIAL GEOGRAPHY.

One-half unit may be offered.

Following is a list of schools whose courses have been approved by the University and whose diplomas will admit to the Freshman class without examination.

ACCREDITED SCHOOLS IN MISSOURI*

FULLY ACCREDITED SCHOOLS

Academy of the Visitation (St. Louis.)
Adrian High School
Albany High School
Anderson High School
Appleton City High School
Armstrong High School
Ash Grove High School
Aurora High School
Ava High School
Belton High School
Bethany High School
Bevier High School
Billings High School
Bloomfield High School
Bolivar High School
Bonne Terre High School
Boonville High School
Bosworth High School
Bowling Green High School
Braymer High School
Breckenridge High School
Brookfield High School
Brunswick High School
Buffalo High School
Bunceton High School
Burlington Junction High School
Butler High School
Cainesville High School
California High School
Cameron High School
Campbell High School
Canton High School
Cape Girardeau High School
Carrollton High School
Carterville High School
Carthage High School
Caruthersville High School
Centralia High School
Charleston High School
Chillicothe High School
Clarence High School
Clayton High School
Clinton High School
Cole Camp High School
Columbia High School
Craig High School
Dearborn High School
De LaSalle Academy (Kansas City)
Desloge High School
DeSoto High School
Dexter High School
Doniphan High School
East Prairie High School
Edgerton High School
Edina High School
Eldon High School
Eldorado Springs High School
Elsberry High School
Eolia High School
Everton High School
Excelsior Springs High School
Fairfax High School
Farmington High School
Fayette High School
Ferguson High School

*Certificates will be accepted from high schools in other States which are affiliated with their respective State Universities provided these are of similar rank with the University of Missouri.

Festus High School
Flat River High School
Fredericktown High School
Fulton High School
Gallatin High School
Garden City High School
Gilman City High School
Glasgow High School
Golden City High School
Gorin High School
Grant City High School
Green City High School
Greenfield High School
Greenville High School
Hale High School
Hamilton High School
Hannibal High School
Hardin High School
Harrisonville High School
Hayti High School
Higbee High School
Higginsville High School
Holden High School
Hopkins High School
Hosmer Hall (St. Louis)
Houston High School
Huntsville High School
Iberia Academy (Iberia)
Independence High School
Ironton High School
Jackson High School
Jamesport High School
Jasper High School
Jefferson City High School
Joplin High School
Kahoka High School
Kansas City Central High School
Kansas City Manual Training High School
Kansas City Northeast High School
Kansas City Westport High School
Kemper Military School (Boonville)
Kennett High School
Kendrick Catholic Boys' High School (St. Louis)
Keytesville High School
Kidder Institute (Kidder)
Kirksville High School
Kirkwood High School
Knobnoster High School
Knox City High School
LaBelle High School
Laclede High School
Lamar High School
Lancaster High School
La Plata High School
Lebanon High School
Lees Summit High School
Lenox Hall (St. Louis)
Lexington High School
Liberty High School
Lockwood High School
Loretto Academy (Kansas City)
Louisiana High School
Macon High School
Maitland High School
Malden High School
Maplewood High School
Marceline High School
Marionville High School
Marshall High School
Marshfield High School
Mary Institute (St. Louis)
Maryville High School
Maysville High School
Meadville High School
Memphis High School
Mexico High School
Milan High School
Moberly High School
Monett High School
Monroe City High School
Montgomery City High School
Mound City High School
Mountain Grove High School
Mt. Vernon High School
Neosho High School
Nevada High School
New Franklin High School
New Hampton High School

New Haven High School
New London High School
Norborne High School
Oak Grove High School
Odessa High School
Oregon High School
Osceola High School
Otterville High School
Ozark High School
Palmyra High School
Paris High School
Pattonsburg High School
Perry High School
Perryville High School
Piedmont High School
Pierce City High School
Platte City High School
Plattsburg High School
Pleasant Hill High School
Polo High School
Poplar Bluff High School
Potosi High School
Princeton High School
Principia, The (St. Louis)
Republic High School
Rich Hill High School
Richmond High School
Ridgeway High School
Rockport High School
Rolla High School
Rosati-Kain High School (St. Louis)
St. Charles High School
Ste. Genevieve High School
St. James High School
St. Joseph Benton High School
St. Joseph Central High School
St. Joseph's Academy (St.Louis)
St. Louis Central High School
St. Louis Cleveland High School
St. Louis McKinley High School
St. Louis Soldan High School
St. Louis Yeatman High School
St. Teresa's Academy (Kansas City)
St. Vincent's Academy (Kansas City)
Salem High School
Salisbury High School
Sarcoxie High School
Savannah High School
Sedalia High School
Seymour High School
Shelbina High School
Shelbyville High School
Sikeston High School
Skidmore High School
Slater High School
Smith Academy (St. Louis)
Smithville High School
Springfield High School
Stanberry High School
Steelville High School
Sturgeon High School
Sullivan High School
Sweet Springs High School
Tarkio High School
Tipton High School
Trenton High School
Troy High School
Union High School
Unionville High School
Vandalia High School
Versailles High School
Walnut Grove High School
Warrensburg High School
Warsaw High School
Washington High School
Webb City High School
Webster Groves High School
Wellston High School
Wellsville High School
Wentworth Military Academy (Lexington)
Weston High School
West Plains High School
Will Mayfield Academy (Marble Hill)
Willow Springs High School
Windsor High School
Wyaconda Consolidated High School

CURRICULA

It is the object of the instruction at this institution, first, to lay a broad and solid foundation by acquaintance with principles and theory, and to supplement this, wherever possible, by the discipline of practical application in the laboratory and field. Lectures and recitations are arranged for the morning hours, leaving the afternoon for laboratory and field work. The practical work is designed to illustrate and impress principles, to familiarize the student with the use of instruments with which he is to be concerned in the work of his profession, and to afford an opportunity for original investigation. What is taught orally in the lecture room is applied and illustrated in the laboratory.

The curricula are the same in the Freshman year and differ but slightly in the Sophomore year. The student has thus an opportunity to defer his choice of a specialty until he has spent some time in technical study, and can better estimate his inclinations and capacities.

One hour is given to each recitation or lecture period. The afternoon periods are given to drawing, laboratory, and field work, and are of three hours' duration; one laboratory period of three hours is rated as equivalent to one and one-half credits.

The School of Mines and Metallurgy offers the following curricula:

I. Mine Engineering, leading to the degree of Bachelor of Science in Mine Engineering. This is a general course in Mine Engineering, having in view all the operations in connection with mining from the prospecting to the delivery of the finished product on the market.

II. Metallurgy, leading to the degree of Bachelor of Science in Metallurgy. This curriculum contemplates especially processes in Metallurgy subsequent to the delivery of ore above ground.

III. Civil Engineering, leading to the degree of Bachelor of Science in Civil Engineering. This is a curriculum in engineering as applied especially to railways, highways, and municipal works.

IV. General Science, leading to the degree of Bachelor of Science in General Science. This curriculum is largely elective and provides for a liberal education in science.

V. Mechanical Engineering, leading to the degree of Bachelor of Science in Mechanical Engineering. This curriculum applies especially to mechanical engineering in shops, mills, ore dressing plants and power plants.

VI. Electrical Engineering, leading to the degree of Bachelor of Science in Electrical Engineering. This is a general course in electrical engineering fitting a man for positions in power plants, transmission plants, central stations and electric railways. The curriculum is so arranged that electives may be chosen in electro-chemistry and electro-metallurgy thus fitting a man for the position of electrical engineer in chemical works and metallurgical plants.

VII. Chemical Engineering, leading to the degree of Bachelor of Science in Chemical Engineering. This curriculum is intended for those who desire to fit themselves for the management of industrial plants in which a knowledge of the principles and methods of chemical analysis and the fundamentals of engineering are required.

VIII. Graduate Curriculum in Mine Engineering, leading to the degree of Engineer of Mines. The curriculum is open to Bachelors of Science in Mine Engineering.

IX. Graduate Curriculum in Metallurgy, leading to the degree of Metallurgical Engineer. This curriculum is open to Bachelors of Science in Metallurgy.

GRADUATE COURSES

The School of Mines offers graduate work in Mining Engineering, Metallurgy, Ore Dressing, Geology, Economic Geology, Petrography, and Advanced Chemistry. The attention of graduates of engineering schools and of mining schools is directed to the following courses:

Mine Management
Mining Machinery
Mining Machinery Laboratory
Mining Law
Mine Examination and Reports
Mine Plant
Mine Plant Design
Mine Power Plant
Mining Economics
Economic Geology
Geology of the United States
Structural and Metamorphic Geology
Petrography
Petrography Laboratory
Cement and Concrete Structures
Compressed Air
Compressed Air Laboratory
Engineering Designs
Ore Dressing Laboratory
Ore Dressing Problems
Ore Supply
Metallurgy Organization
Metallography
Constitution of Alloys
Metallurgical Problems
Metallurgical Plant
Metallurgical Plant Design
Cyaniding
Electro-Metallurgy
Electro-Metallurgy Laboratory
Metallurgical Research
Electro-Chemistry
Water Analysis
Physical Chemistry
Theoretical Chemistry
Advanced Physico-Chemical Laboratory
Internal Combustion Engines

Graduates from the four-year curriculum in Mining Engineering may pursue graduate work leading to the degree of Engineer of Mines. Electives may be chosen along any line approved by the Faculty.

A similar graduate curriculum is offered in Metallurgy. This leads to the degree of Metallurgical Engineer.

SPECIAL COURSES

In addition to the regular curricula leading to degrees, before mentioned, a number of shorter courses are also offered. They are: *Chemistry and Assaying, Mining, Surveying, and Electricity.* They have been planned for the benefit of those who for various legitimate reasons are unable to take the regular four-year courses.

The course in *Assaying and Chemistry* requires two years' work, although mature students, who have already some knowledge of chemistry, may complete it in one year.

The purpose of the course in *Surveying* is to develop competent land and mining surveyors and fair draftsmen. The essentials of it are a thorough knowledge of algebra, trigonometry, surveying, field practice, and drawing. One school year and the first term of a second year will be required for the completion of this course.

A short course in *Mining* is offered to students, especially such as have had some practical experience, who may wish to fit themselves for holding important positions about mines or in ore-dressing plants, but who are unable, on account of the lack of preparation or of time, to take the full course in Mining Engineering. Besides mathematics this course includes general chemistry, assaying, mineralogy, mining, surveying and English.

A course in *Electricity* is offered to furnish the student with the theory of electricity and acquaint him with its application in the arts. This subject is of great importance to every engineer, especially to the mining engineer, since electricity has become such an important factor in mining operations.

DEGREES

I. The degree of Bachelor of Science in Mine Engineering will be conferred upon a candidate for a degree who has completed the prescribed work of Curriculum I., and all of the required trips of Curriculum I. The final year's work must be done in residence.

II. The degree of Bachelor of Science in Metallurgy will be conferred upon a candidate for a degree who has completed the prescribed work of Curriculum II., and all of the trips required in Curriculum II. The final year's work must be done in residence.

III. The degree of Bachelor of Science in Civil Engineering will be conferred upon a candidate for a degree who has completed the prescribed work of Curriculum III. The final year's work must be done in residence.

IV. The degree of Bachelor of Science in General Science will be conferred upon a candidate who has completed the prescribed work of Curriculum IV. Candidates for degrees in General Science must matriculate in General Science Curriculum not later than the beginning of the second semester of the sophomore year. The final year's work must be done in residence.

V. The degree of Bachelor of Science in Mechanical Engineering will be conferred upon a candidate who has completed the prescribed work of Curriculum V. The final year's work must be done in residence.

VI. The degree of Bachelor of Science in Electrical Engineering will be conferred upon a candidate for a degree who has completed the prescribed work of Curriculum VI. The final year's work must be done in residence.

VII. The degree of Bachelor of Science in Chemical Engineering will be conferred upon a candidate for a degree who has completed the prescribed work of Curriculum VII. The final year's work must be done in residence.

VIII. The degree of Engineer of Mines, Metallurgical Engineer, will be conferred upon a candidate who holds a degree of Bachelor of Science in Mine Engineering or Bachelor of Science in Metallurgy, respectively, and who has completed, in residence, one year of post graduate work.

IX. The degree of Engineer of Mines, Metallurgical Engineer, Civil Engineer, Mechanical Engineer, Electrical Engineer, or Chemical Engineer will be conferred upon a candidate who holds a degree of Bachelor of Science in Mine Engineering, Bachelor of Science in Metallurgy, Bachelor of Science in Civil Engineering, Bachelor of Science in Mechanical Engineering, Bachelor of Science

in Electrical Engineering, or Bachelor of Science in Chemical Engineering who has had professional experience in a responsible position for not less than three years. A satisfactory thesis recording the result of some original investigation or independent research in a subject connected with his work, accompanied by such drawings as may be necessary to illustrate it, is required of each candidate for an advanced degree.

A candidate for a professional degree is required to submit a list of companies for whom he has worked, with the positions held, the kind of work done, and the length of service.

When a candidate's professional work has been along another line than that in which he received his college training, he may receive the professional degree in that line after five years of practice and by complying with the foregoing statement concerning detailed report of employment and thesis. This applies only to graduates in I., II., III., V., VI., and VII.

Only one professional degree will be allowed for work done *in absentia.*

X. The degree of Master of Science will be conferred only upon graduates in General Science who have completed a year's graduate work in residence and demonstrated ability by research work and a thesis. Each candidate who is not a graduate of this institution in Curriculum IV. must satisfy the language requirements of Curriculum IV., in addition to completing the graduate requirements. A candidate who is not giving his entire time to graduate study will be unable to earn the degree in one year's residence.

THESES

Seniors may elect, subject to the approval of the head of the Department, to carry on special investigations embodying the results of their work in a thesis. The subject of the thesis must be reported to the Thesis Committee of the Faculty and approved not later than February first. The completed thesis must be filed with the Director not later than May twentieth.

The finished thesis should be typewritten (or printed) on eight and one-half by eleven-inch paper, written on one side only. The paper should be strong linen, unruled and without marginal lines.

The thesis should be typewritten so as to have a margin all around of not less than one and one-half inches.

Thesis paper should not be punched with holes for staples.

Theses, when submitted, should not be stapled, sewed, or bound in any manner, but should be on loose sheets, in order that all theses may be bound uniformly by the Library.

Drawings, tracings, blue prints, diagrams, statistical tables, etc., when on a single 8½x11 inch sheet, should allow a margin of at least 1½ inches on the inner (long) edge, for binding purposes. When on a larger sheet, requiring folding, large margin should be allowed on all sides, and drawings should not be folded, but submitted flat or rolled, in order that they may be properly folded and adjusted by the binder. It is suggested that students confer with the Librarian in regard to the preparation of drawings, diagrams, tracings, etc.

The thesis should have:

(1) A title page containing the subject of the thesis, the writer's name, and the date. It should show the approval of the professor under whose direction the work has been done and should also state the degree for which the candidate is an applicant.
(2) A table of contents.
(3) A list of illustrations.
(4) The body of the thesis including illustrations.
(5) A bibliography.
(6) An index.
(7) Original drawings or tracings.

All theses submitted by candidates for degrees become the property of the School of Mines and Metallurgy and may not be published without its approval.

I. MINE ENGINEERING CURRICULUM.

Department.	No.	Course.	Page.....	Hrs. per week. Lect..	Hrs. per week. Lab..	Hours credit...
FRESHMAN YEAR.						
First Semester.						
Chemistry	1a	General Chemistry	54	4	....	4
Chemistry	2a	Chemistry Laboratory	54	....	3	1.5
English	1a	Rhetoric and Composition	76	3	....	3
Modern Languages*	7a	German	78			
Modern Languages*	11a	French, or	79	3	....	3
Modern Languages*	15a	Spanish	79			
Mathematics	1a	College Algebra	89			
Mathematics	3a	Plane Trigonometry	89	5	....	5
Mechanical Engineering	2a	Mechanical Drawing	97	....	6	3
Mechanical Engineering	12a	Woodwork	100	....	3	1.5
Gymnasium	.....	.....	....	....	2	0
Second Semester.						
Chemistry	1b	General Chemistry	54	3	....	3
Chemistry	2b	Chemistry Laboratory	54	....	3	.5
English	1b	Rhetoric and Composition	76	3	....	3
Modern Languages	7b	German	78			
Modern Languages	11b	French, or	79	3	....	3
Modern Languages	15b	Spanish	79			
Mathematics	5b	Spherical Trigonometry	89			
Mathematics	7b	Analytical Geometry	90	5	....	5
Mechanical Engineering	1b	Descriptive Geometry	97	1	3	2.5
Mechanical Engineering	2b	Mechanical Drawing	97	....	3	1.5
Mechanical Engineering	14b	Forge Shop	100	....	3	1.5
Gymnasium	.....	.....	....	....	2	0

*Those looking forward to Chemical Engineering or to the Mining Geology option are advised to take either French or German to satisfy the language requirement.

I. MINE ENGINEERING CURRICULUM—*Continued.*

Department.	No.	Course.	Page.....	Hrs. per week.		Hours credit...
				Lect..	Lab..	
SOPHOMORE YEAR.						
First Semester.						
Chemistry	4a	Qualitative Analysis	55	....	6	3
Civil Engineering	2a	Plane Surveying	68	....	6	3
English	3a	English Prose	76	3	....	3
Geology and Mineralogy	1a	Mineralogy	82	1	3	2.5
Mathematics	9a	Differential Calculus	90			
Mathematics	11a	Integral Calculus	90	4	....	4
Physics	1a	General Physics	128	3	....	3
Physics	2a	Physics Laboratory	128	....	3	1.5
Second Semester.						
Chemistry	6b	Quantitative Laboratory	56	....	6	3
English	3b	English Prose	77	2	....	2
Geology and Mineralogy	1b	Mineralogy	82	1	6	4
Mathematics	11b	Integral Calculus	90			
Mathematics	13b	Differential Equations	90	4	....	4
Mechanics	17b	Mechanics	94	4	....	4
Physics	3b	General Physics	129	3	....	3
Physics	4b	Physics Laboratory	129	....	3	1.5
JUNIOR YEAR.						
First Semester						
Chemistry	6a	Quantitative Laboratory	56	....	6	3
Civil Engineering	7a	Railroad Surveying	69	1	3	2.5
Geology and Mineralogy	3a	General Geology	83	3	....	3
Mechanics	19a	Mechanics of Materials	94	4	....	4
Metallurgy	1a	Fire Assaying	106	2	....	2
Metallurgy	2a	Assaying Laboratory	107	....	6	3
Mining	3a	Mining	122	3	....	3
Mining	16a	Mining Laboratory	124	....	3	1.5
Second Semester.						
Geology and Mineralogy	3b	General Geology	83	3	....	3
Geology and Mineralogy	4b	Geology Laboratory	83	....	6	3
Geology and Mineralogy	5b	Lithology	84	1	3	2.5
Mechanical Engineering	5b	Boilers and Engines	98	3	....	3
Mechanical Engineering	8b	Mechanical Laboratory	99	....	6	3
Metallurgy and Ore Dressing	39b	General Metallurgy	116	3	....	3
Mining	5b	Mine Surveying	122	2	....	2
Mining	6b	Mine Surveying Laboratory	123	....	3	1.5

I. MINE ENGINEERING CURRICULUM—*Continued.*

Department.	No.	Course.	Page.....	Hrs. per week.		Hours credit...
				Lect.	Lab.	
SENIOR YEAR.						
First Semester.						
Geology and Mineralogy...	9a	Economic Geology.....	84	4	....	4
Metallurgy and Ore Dressing.....	5a	Metallurgy.....	108	4	....	4
Metallurgy and Ore Dressing.....	6a	Metallurgy Laboratory.....	110	....	3	1½
Metallurgy and Ore Dressing.....	33a	Ore Dressing.....	115	3	....	3
Physics and E. E.....	7a	Principles of E. E.....	129	3	....	3
Physics and E. E.....	8a	Dynamo Laboratory.....	130	....	3	1½
Electives.....	.....	.....	....	....	....	4
Second Semester.						
Geology and Mineralogy... or	9b	Economic Geology.....	85			
Metallurgy and Ore Dressing.....	5b	Metallurgy.....	110	3	....	3
Metallurgy and Ore Dressing.....	33b	Ore Dressing.....	115	3	....	3
Metallurgy and Ore Dressing.....	36b	Ore Dressing Laboratory...	116	....	6	3
Mining.....	11b	Mining.....	123	3	....	3
Mining.....	19b	Economics and Contracts...	124	2	....	2
Physics and E. E.....	7b	Principles of E. E.....	129	3	....	3
Physics and E. E.....	8b	Dynamo Laboratory.....	130	....	3	1½
Electives.....	.....	.....	....	....	....	2½

Electives must be selected from the following courses: Civil Engineering 9a; English and Modern Language 17a, 17b, 19a; Mechanical Engineering 3a, 9a, 11a; Metallurgy and Ore Dressing 13a, 41b.

Those who wish to specialize in coal mining may omit Metallurgy and Economic Geology and take mine ventilation and Power Plants as required courses, and may have fuel analysis added to the list of electives.

Those who wish to specialize in Geology may omit Metallurgy, Principles of Electrical Engineering, and Dynamo Laboratory and take Field Geology and Structural Geology as required courses and may have Geology of the United States, Oil and Gas, Geology Conference and Petrography added to the list of electives.

II. METALLURGY CURRICULUM.

Freshman year is the same as Curriculum I.
Sophomore year either Curriculum I or Curriculum VII.

Department.	No.	Course.	Page.....	Hrs. per week.		Hours credit...
				Lect..	Lab..	
JUNIOR YEAR.						
First Semester.						
Chemistry.....	6a	Quantitative Laboratory....	56	....	6	3
Chemistry.....	7a	Physical Chemistry.....	56	2	6	5
Geology and Mineralogy...	3a	General Geology.....	83			
or				3	....	3
Chemistry.....	15a	Eng. Chemistry.....	58			
Mathematics.....	19a	Mechanics of Materials.....	94	4	....	4
Physics and E. E.....	7a	Principles of E. E.....	129	3	....	3
or Civil Engineering.....	7a	Railroad Surveying.....	69	1	3	2½
or Physics and E. E.....	8a	Dynamo Laboratory.....	130	....	5	2½
Second Semester.						
Chemistry.....	9b	Electro-chemistry.....	57	2	6	5
Metallurgy and Ore Dressing.....	1b	Assaying.....	106	2	....	2
Metallurgy and Ore Dressing.....	2b	Assaying Laboratory.....	107	....	9	4½
Metallurgy and Ore Dressing.....	41b	Iron and Steel.....	117	3	....	3
Metallurgy and Ore Dressing.....	39b	General Metallurgy.....	116	3	3	4½
Physics and E. E.....	7b	Principles of E. E.....	129	3	....	3

SENIOR YEAR;—Fourteen lectures and fifteen laboratory hours each semester. Metallurgy and Ore Dressing 5a, 5b, 6a, 33a, and 33b, and the Senior Trip must be included.

III. CIVIL ENGINEERING CURRICULUM.

The Freshman Year is the same as in I.

Department.	No.	Course.	Page.	Hrs. per week. Lect.	Hrs. per week. Lab.	Hours credit.
SOPHOMORE YEAR.						
First Semester.						
Civil Engineering	2a	Plane Surveying	68	....	6	3
Civil Engineering	4a	Engineering Details	69	....	3	1½
English	3a	English Prose	76	3	....	3
Modern Languages	9a	Advanced German	78			
Modern Languages	13a	Advanced French	79	3	....	3
Modern Languages	17a	Advanced Spanish	80			
Geology and Mineralogy	2a	Mineralogy	82	....	3	1½
Mathematics	9a	Differential Calculus	90			
Mathematics	11a	Integral Calculus	90	4	....	4
Physics	1a	General Physics	128	3	....	3
Physics	2a	Physics Laboratory	128	....	3	1½
Second Semester.						
Civil Engineering	3b	Higher Surveying	69	....	9	4½
English	3b	English Prose	77	2	....	2
Modern Languages	9b	Advanced German	78			
Modern Languages	13b	Advanced French	79	2	....	2
Modern Languages	17b	Advanced Spanish	80			
Mathematics	11b	Integral Calculus	90			
Mathematics	13b	Differential Calculus	90	4	....	4
Mathematics	17b	Mechanics	94	4	....	4
Physics	3b	General Physics	129	3	....	3
Physics	4b	Physics Laboratory	129	....	3	1½

III. CIVIL ENGINEERING CURRICULUM—*Continued.*

The Freshman Year is the same as in I.

Department.	No.	Course.	Page.....	Hrs. per week.		Hours credit...
				Lect..	Lab..	
JUNIOR YEAR.						
First Semester.						
Civil Engineering.....	7a	Railroad Surveying.....	69	1	3	2½
Civil Engineering.....	9a	Hydraulics.....	70	3	3	4½
Civil Engineering.....	11a	Masonry.....	70	2	....	2
Civil Engineering.....	20a	Materials Laboratory.....	73	....	6	3
Geology and Mineralogy...	3a	General Geology.....	83	3	....	3
Mathematics.....	19a	Mechanics of Materials.....	94	4	....	4
Mechanical Engineering...	5a	Boilers and Engines.....	98	3	....	3
Second Semester.						
Civil Engineering.....	7b	Railroad Construction.....	70	2	....	2
Civil Engineering.....	11b	Masonry.....	71	2	3	3½
Civil Engineering.....	13b	Highways.....	71	3	....	3
Civil Engineering.....	15b	Stresses.....	72	2	6	5
Geology and Mineralogy...	3b	General Geology.....	83	3	....	3
Geology and Mineralogy...	4b	Geology Laboratory.....	83	....	6	3
Mechanical Engineering...	6b	Steam Laboratory.....	98	....	3	1½
SENIOR YEAR.						
First Semester.						
Civil Engineering.....	15a	Frame Structures.....	72	3	6	6
Civil Engineering.....	19a	Water.....	72	3	....	3
Civil Engineering.....	31a	Masonry Design.....	75	3	6	6
		Electives.....	....	....	....	6
Second Semester.						
Civil Engineering.....	25b	Structural Design.....	74	3	9	7½
Civil Engineering.....	29b	Sanitary Engineering.....	75	3	....	3
Mining.....	19b	Contracts.....	124	2	....	2
		Electives.....	....	....	....	8½

Electives must be selected from the following courses: Irrigation, Railroad Economics, Mining, Mine Surveying, Metallurgy of Iron and Steel, Principles of Electrical Engineering, Dynamo Laboratory, and Engineering Writing.

IV. GENERAL SCIENCE CURRICULUM.

The Freshman Year is the same as in I.

Department.	No.	Course.	Page.....	Hrs. per week.		Hours credit...
				Lect..	Lab. .	
SOPHOMORE YEAR.						
First Semester.						
Chemistry.....	4a	Quantitative Laboratory....	55	....	6	3
English and.....	3a	English Prose.....	76	3	....	3
Modern Languages.....	9a	Advanced German, or.....)	78			
Modern Languages.....	13a	Advanced French.....)	79	3	....	3
Geology and Mineralogy...	1a	Mineralogy.....	82	1	3	2½
Mathematics.....	9a	Differential Calculus.....)	90			
Mathematics.....	11a	Integral Calculus.....)	90	4	....	4
Physics.....	1a	General Physics.....	128	3	....	3
Physics.....	2a	Physics Laboratory.....	128	....	3	1½
Second Semester.						
English.....	3b	English Prose.....	77	2	....	2
Modern Languages.....	9b	Advanced German or.....)	78			
Modern Languages.....	13b	Advanced French.....)	79	2	....	2
Physics.....	3b	General Physics.....	129	3	3	4½
		Electives.....	....	....	....	13½
JUNIOR YEAR.						
First Semester.						
English.....	5a	Shakespeare.....	77	3	....	3
		Electives.....	....	....	....	18
Second Semester.						
English.....	5b	Contemporary Drama.....	77	3	....	3
		Electives.....	....	....	....	18

Senior Year, 21 Electives each semester.

In making up his electives in Curriculum IV, the student must select a major field and a minor field. In the former, he is required to complete 50 credit hours and in the latter 25 credit hours. Twelve hours are freely elective.

The student shall choose his major and minor at the beginning of the second semester of the Sophomore Year, and his schedule must be approved by the heads of the departments in whose fields he proposes to study.

V. MECHANICAL ENGINEERING CURRICULUM.

The Freshman Year is the same as in I.

Department.	No.	Course.	Page.....	Hrs. per week.		Hours credit...
				Lect..	Lab.	
SOPHOMORE YEAR.						
First Semester.						
Civil Engineering	2a	Plane Surveying	68	....	6	3
English	3a	English Prose	76	3	....	3
Mathematics	9a	Differential Calculus	90			
Mathematics	11a	Integral Calculus	90	4	....	4
Mechanical Engineering	4a	Machine Drawing	98	....	4	2
Mechanical Engineering	16a	Foundry	101	....	3	1½
Physics	1a	General Physics	128	3	....	3
Physics	2a	Physics Laboratory	128	....	3	1½
		Elective	....	....	....	3
Second Semester.						
Chemistry	34b	Fuel Analysis	64	....	3	1½
English	3b	English Prose	76	2	....	2
Mathematics	11b	Integral Calculus	90			
Mathematics	13b	Differential Equations	90	4	....	4
Mechanical Engineering	18b	Machine Shop	102	....	6	3
Mechanics	17b	Mechanics	94	4	....	4
Physics	3b	General Physics	129	3	....	3
Physics	4b	Physics Laboratory	129	....	3	1½
		Elective	....	....	....	2

V. MECHANICAL ENGINEERING CURRICULUM—*Continued.*

The Freshman Year is the same as in I.

Department.	No	Course.	Page	Hrs. per week. Lect.	Hrs. per week. Lab.	Hours credit.
JUNIOR YEAR.						
First Semester.						
Civil Engineering	9a	Hydraulics	70	3	3	4½
Mathematics	19a	Mechanics of Materials	94	4	....	4
Mechanical Engineering	3a	Mechanism	98	3	....	3
Mechanical Engineering	5a	Boilers and Engines	98	3	....	3
Mechanical Engineering	20a	Machine Design	102	....	6	3
		Electives	....	....	....	4
Second Semester.						
Civil Engineering	20b	Materials Laboratory	73	....	3	1½
Mechanical Engineering	7b	Valve Gears	99	2	....	2
Mechanical Engineering	8b	Mechanical Laboratory	99	....	6	3
Mechanical Engineering	9b	Thermodynamics	100	3	....	3
Mechanical Engineering	20b	Engine Design	103	....	6	3
Metallurgy and Ore Dressing	41b	Metallurgy of Iron and Steel	117	3	....	3
		Electives	....	....	....	5
SENIOR YEAR.						
First Semester.						
Mechanical Engineering	9a	Power Plants	99	3	3	4½
Mechanical Engineering	24a	Power Plant Design	103	....	6	3
Physics and E. E	7a	Principles of E. E	129	3	....	3
Physics and E. E	8a	Dynamo Laboratory	130	....	3	1½
		Electives	....	....	....	13
Second Semester.						
Mechanical Engineering	19b	Industrial Engineering	102	3	....	3
Mining	19b	Contracts	124	2	....	2
Physics and E. E	7b	Principles of E. E	129	3	....	3
Physics and E. E	8b	Dynamo Laboratory	130	....	3	1½
		Electives	....	....	....	11½

Compressed Air, Internal Combustion, Engines, Heating and Ventilating, Refrigeration, Ore Dressing, Alloys and Metallography, and Engineering Writing may be chosen as electives.

VI. ELECTRICAL ENGINEERING CURRICULUM.

The Freshman Year is the same as in I.

Department.	No.	Course.	Page.....	Hrs. per week.		Hours credit...
				Lect..	Lab. .	
SOPHOMORE YEAR.						
First Semester.						
Civil Engineering.....	2a	Plane Surveying.....	68	....	6	3
English.....	3a	English Prose.....	76	3	....	3
Mathematics.....	9a	Differential Calculus.....	90			
Mathematics.....	11a	Integral Calculus.....	90	4	....	4
Mechanical Engineering...	4a	Machine Drawing.....	98	....	4	2
Mechanical Engineering...	16a	Foundry.....	101	....	3	1½
Physics.....	1a	General Physics.....	128	3	....	3
Physics.....	2a	Physics Laboratory.....	128	....	3	1½
		Elective.....	....	....	....	3
Second Semester.						
Chemistry.....	34b	Fuel Analysis.....	64	....	3	1½
English.....	3b	English Prose.....	77	2	....	2
Mathematics.....	11b	Integral Calculus.....	90			
Mathematics.....	13b	Differential Equations.....	90	4	....	4
Mechanics.....	17b	Mechanics.....	94	4	....	4
Mechanical Engineering...	18b	Machine Shop.....	102	....	6	3
Physics.....	3b	General Physics.....	129	3	....	3
Physics.....	4b	Physics Laboratory.....	129	....	3	1½
		Elective.....	....	....	....	2

VI. ELECTRICAL ENGINEERING CURRICULUM—*Continued.*

The Freshman Year is the same as in I.

Department.	No.	Course.	Page.....	Hrs. per week. Lect..	Hrs. per week. Lab..	Hours credit..
JUNIOR YEAR.						
First Semester.						
Civil Engineering.....	9a	Hydraulics.....	70	3	3	4½
Mathematics.....	19a	Mechanics of Materials.....	94	4	....	4
Physics and E. E.....	7a	Principles of E. E.....	129	3	....	3
Physics and E. E.....	8a	Dynamo Laboratory.....	130	....	3	1½
Mechanical Engineering...	3a	Mechanism.....	98	3	....	3
Mechanical Engineering...	5a	Boilers and Engines.....	98	3	....	3
Mechanical Engineering...	22a	Machine Design.....	103	....	3	1½
Second Semester.						
Civil Engineering.....	20b	Materials Laboratory.....	73	....	3	1½
Mechanical Engineering...	6b	Steam Laboratory.....	98	....	3	1½
Mechanical Engineering...	9b	Thermodynamics.....	100	3	....	3
Metallurgy and Ore Dressing.....	41b	Metallurgy of Iron and Steel	117	3	....	3
Physics and E. E.....	7b	Principles of E. E.....	129	3	....	3
Physics and E. E.....	8b	Dynamo Laboratory.....	130	....	3	1½
Physics and E. E.....	10b	Electrical Laboratory.....	130	....	6	3
		Electives.....	....	....	....	5
SENIOR YEAR.						
First Semester.						
Mechanical Engineering...	9a	Power Plants.....	99	3	3	4½
Physics and E. E.....	11a	Electrical Machinery.....	130	2	3	3½
Physics and E. E.....	13a	Alternating Currents.....	131	5	....	5
		Electives.....	....	....	....	8
Second Semester.						
Mining.....	19b	Contracts.....	124	2	....	2
	11b	Electrical Machinery.....	130	2	3	3½
Physics and E. E.....	13b	Alternating Currents.....	131	5	....	5
Physics and E. E.....	19b	Electrical Distribution.....	131	3	....	3
		Electives.....	....	....	....	7½

Electric Railways, Electro-Metallurgy, Electro-Chemistry, Electrical Transmission and Power Engineering, Engineering Writing and advanced Modern Languages may be chosen as electives.

VII. CHEMICAL ENGINEERING CURRICULUM.

The Freshman year is the same as Curriculum I.

Department.	No.	Course.	Page.	Hrs. per week. Lect.	Hrs. per week. Lab.	Hours credit.
SOPHOMORE YEAR.						
First Semester.						
Chemistry	31a	Analytical Chemistry	63	2	....	2
Chemistry	32a	Analytical Laboratory	63	....	8	4
English	3a	English Prose	76	3	....	3
Modern Languages	9a	Advanced German	78			
Modern Languages	13a	Advanced French	79	3	....	3
Geology and Mineralogy	2a	Mineralogy	82	....	3	1½
Mathematics	9a	Differential Calculus	90			
Mathematics	11a	Integral Calculus	90	4	....	4
Physics	1a	General Physics	128	3	....	3
Physics	2a	Physics Laboratory	128	....	3	1½
Second Semester.						
Chemistry	32b	Quantitative Laboratory	64	....	9	4½
English	3b	English Prose	77	2	....	2
Modern Languages	9b	Advanced German	78			
Modern Languages	13b	Advanced French	79	2	....	2
Mathematics	11b	Integral Calculus	90			
Mathematics	13b	Differential Equations	90	4	....	4
Mechanics	17b	Mechanics	94	4	....	4
Physics	3b	General Physics	129	3	....	3
Physics	4b	Physics Laboratory	129	....	3	1½
JUNIOR YEAR.						
First Semester.						
Chemistry	21a	Organic Chemistry	61	3	6	6
Chemistry	31a	Physical Chemistry	63	3	9	7½
Mechanics	19a	Mechanics of Materials	94	4	....	4
Mechanical Engineering	5a	Boilers and Engines	98	3	....	3
Second Semester.						
Chemistry	21b	Organic Chemistry	61	3	6	6
Chemistry	23b	Chemical Economics	61	3	....	3
Chemistry	25b	Applied Electro-Chemistry	62	2	6	5
Mechanical Engineering	6b	Steam Laboratory	98	....	3	1½
Metallurgy and Ore Dressing	1b	.....	106	2	....	2
Metallurgy and Ore Dressing	2b	Assay Laboratory	107	....	3	1½
Metallurgy and Ore Dressing	39b	General Metallurgy	116	3	....	3

VII. CHEMICAL ENGINEERING CURRICULUM—*Continued.*

Senior Year.
Required Chemistry 17a, 18a, 17b, and 29b.
Electives, 30 semester hours elected from the following courses:
Chemistry, 18b, 24b, 113a, 113b, 114b, 120a, 122b.
Civil Engineering, 2a, 15a, 17a, and 20b.
English 19a.
Mechanical Engineering 9a, 10a, 18a.
Metallurgy and Ore Dressing 29a, 30a, 33a.
Physics and E. E. 7a, 8a, 7b, and 8b.

Candidates for the degree in Curriculum VII shall not take more than half of their senior work in the department of Chemistry.

VIII. GRADUATE CURRICULUM IN MINE ENGINEERING.

Graduates of this or other institutions of equal rank who have received the degree of Bachelor of Science in Mine Engineering may matriculate for a course of graduate study and research in Mine Engineering. The minimum requirement is the completion of forty semester hours including a thesis.

Candidates for degrees must give half their time to work upon a major subject which must be in the Department of Mining, Geology, or Metallurgy and Ore Dressing. At least one-fourth of the work must be done in one of the other departments noted above. The major and the minor subjects must be approved by the Faculty before the student enters upon the work. A suitable thesis subject must be approved.

IX. GRADUATE CURRICULUM IN METALLURGY.

Graduates of this school or of other institutions of equal rank who have completed a course of study leading to the degree of Bachelor of Science in Metallurgy may undertake advanced work leading to the degree of Metallurgical Engineer. The minimum requirement is forty semester hours including a thesis.

Candidates for the degree of Metallurgical Engineer must give half their time to work upon a major subject in the Department of Metallurgy and Ore Dressing. At least ten units work shall be upon a minor subject in another department. The major, the minor, and the thesis subjects must be approved by the faculty.

NORWOOD HALL,

CHEMISTRY BUILDING.

CHEMISTRY

Professor Gottschalk,* Assistant Professors Ingram and Hammond, Mr. Ambler, Mr. Lang, Mr. Nichols, Mr. Terry, Mr. Lane.

Equipment.

One entire building is devoted to chemistry. The main chemical lecture room occupies the entire south wing of the building. The laboratories for general chemistry and for qualitative analysis, on the first floor of the main building, accommodate together about one hundred forty students. The quantitative laboratories on the second floor have desk room for seventy-five students working at one time. In the north wing is a smaller lecture room, as well as a capacious laboratory for advanced students.

Excellent ventilation is provided by a thirteen-horsepower motor and suction fan connected with individual hoods over each laboratory desk and with the long lines of fume chambers distributed throughout the building. Gas, water, and air blast are supplied conveniently, while a steam-heated still of five gallons an hour capacity furnishes ample distilled water.

The equipment includes twenty-four first-class analytical balances, sixty sets of good analytical weights, sixty sets of volumetric instruments with Bureau of Standards stamps, several complete sets of gas analysis apparatus, standard instruments for the physical and chemical testing of petroleum and its products, a liberal supply of platinum ware, and a good selection of precision instruments for physico-chemical and electro-chemical measurements.

The department has secured the co-operation of some of the chemical manufacturing concerns and is preparing for exhibition a Museum of Industrial Chemistry. Exhibits of the raw material and products illustrating the processes in many of the industries have already been received and are being arranged for display.

The appropriation made for equipping an Industrial Laboratory will provide adequate machinery and accessories to erect, in the north wing of the Chemical Building, a number of complete miniature industrial works. The machines installed will probably include a double-effect evaporator, vacuum pan, steam kettles, mixing machines, filter presses, apparatus for distillation and rectification, grinding machinery, and the incidentals necessary for the

*On leave 1916-1917.

preparation of commercial chemicals, soap, paints, dyed textiles, wood products, acids, oils, leather.

With the proposed rearrangement of the building more space will be available for laboratory work in organic, physical, and electro-chemistry, as well as in the applied chemistry.

Courses.

1a. GENERAL CHEMISTRY. *Lectures.* (Ingram)

This course is a comprehensive study of the general principles of chemistry and of the more important non-metals. The fundamental laws of chemistry are developed in logical order, special attention being given to their application in practical computations. Carefully designed lecture experiments are a feature of the course. The class is divided into several smaller sections for recitation and discussion of problems.

Prerequisites: Entrance requirements.

Required in I., II., III., IV., V., VI., and VII.

Freshman year, first semester, five hours per week. Credit five hours.

Text: McPherson and Henderson, *A Course in General Chemistry.*

Ashley, *Chemical Calculations.*

In 1917-18 this course will be four hours per week.

1b. GENERAL CHEMISTRY. *Lectures.* (Ingram)

Continuation of course 1a; devoted to the chemistry of the metals, with special consideration of the reactions employed in analytical chemistry, in metallurgy, and in geology. The ionic theory, phase rule, and mass-law are introduced and applied at advantageous points in the lectures.

The course concludes with a series of lectures on elementary applied chemistry.

Prerequisites: Chemistry 1a and 2a.

Required in I., II., III., IV., V., VI., and VII.

Freshman year, second semester, five hours per week. Credit five hours.

Text: Same as in 1a.

In 1917-18 this course will be three hours per week.

2a. GENERAL CHEMISTRY. *Laboratory.*

(Ingram, Lang, Nichols)

The laboratory work accompanying general chemistry consists of experiments which are largely quantitative, and which are intended to teach stoichiometrical relations from the first.

Prerequisite: Must be accompanied by Chemistry 1a.

Required in I., II., III., IV., V., VI., and VII.

Freshman year, first semester, six hours per week. Credit three hours.

Text: C. M. Allen, *Exercises in General Chemistry.*

In 1917-18 this course will be three hours per week each semester.

3b. QUALITATIVE ANALYSIS. *Lectures.* (Ingram)

This course is an exposition of the principles underlying the qualitative separation and identification of the commoner elements found in minerals, rocks, and metallurgical products.

Prerequisites: Chemistry 1a and 2a and accompanied by 1b.

Required in I., II., III., IV.

Freshman year, second semester, two hours per week. Credit two hours.

Text: A. A. Noyes, *Qualitative Analysis.*
Manuscript Notes.

Discontinued after 1916-17.

4b. QUALITATIVE ANALYSIS. *Laboratory.*
(Ingram, Lang, Nichols)

The student is drilled in the practical separation and identification of ordinary mineral constituents, the examples for practice consisting of solutions, mixtures of salts, alloys, and ores. Wet methods are followed entirely with the exception of a few tests by means of the spectroscope.

Prerequisite: Chemistry 2a, and must be accompanied by 3b.

Required in I., II., III., and IV.

Freshman year, second semester, six hours a week. Credit three hours.

Text: A. A. Noyes, *Qualitative Analysis.*
Manuscript Notes.

In 1917-18 this course will be sophomore year, first semester, six hours per week.

5a. QUANTITATIVE ANALYSIS. *Lectures.* (Ambler)

The subjects discussed in this course are as follows: The balance, weights, and the process of weighing; simple gravimetric analysis; analysis of silicate rocks, and application to clay, shale, and slag analysis; volumetric instruments, their calibration and use; volumetric analysis, standard solutions, indicators; technical volumetric methods in general, wet assaying of copper, zinc, and lead ores and concentrates. Problems in the calculations of analytical chemistry are also discussed.

Prerequisites: Chemistry 3b, 4b.

Required in I., and II.

Sophomore year, first semester, two hours per week. Credit two hours.

Text: *Manuscript Notes.*
Miller, *Calculations of Analytical Chemistry.*

Discontinued after 1916-17.

6a. QUANTITATIVE ANALYSIS. *Laboratory.*

(Ambler, Terry)

Before beginning actual quantitative analysis, the student is required to make a careful study of the balance and of the method of weighing. The rest of the time is given to exercises in simple gravimetric analysis, with some volumetric analysis, chiefly on analyzed mixtures, closing with a (technical) clay analysis.

Prerequisites: Chemistry 3b, 4b, and must be accompanied by 5a.

Required in I., and II.

Sophomore year, first semester, six hours per week. Credit three hours.

Text: Moody, *Quantitative Analysis.*

In 1917-18 this course will be sophomore year, second semester.

6b. QUANTITATIVE ANALYSIS. *Laboratory.*

(Ambler, Terry)

Technical methods for the determination of copper, lead, zinc, arsenic, antimony, sulphur, and coal analysis. Essential parts of the course are the speed tests, in which students are required to report correct results on a number of copper, zinc, and lead ores within a stated time.

Actual ores, analyzed by the instructing staff, are on hand in quantity, and the students are trained to attain the same degree of accuracy which obtains in smelter laboratories.

Prerequisite: Chemistry 6a.

Required in I., and II.

Sophomore year, second semester, nine hours per week. Credit 4.5 hours. Six hours per week for students in curriculum I. Credit 3 hours.

Text: Seamon, *Manual for Assayers and Chemists.*
Low, *Ore Analysis.*

In 1917-18 this course will be Junior year, first semester.

7a. PHYSICAL CHEMISTRY. *Lectures.* (Hammond)

This course is intended as an introduction to physical chemistry. The qualitative and quantitative theories of chemical equilibria as given by the phase rule and by the mass law are studied first. Towards the end of the term the basis of the ionic theory is discussed.

Prerequisite: Chemistry 4b.

Required in II.

Sophomore year, first semester, two hours per week. Credit two hours.

Discontinued after 1916-17. See 35a.

7b. ANALYTICAL CHEMISTRY. *Lectures.* (Hammond)

The application of the ionic theory to analytical chemistry is taken up in detail; a select number of lecture experiments illustrate the main propositions advanced.

Prerequisite: Chemistry 7a.

Required in II.

Sophomore year, second semester, two hours per week. Credit two hours.

Text: Stieglitz, *Qualitative Analysis, Part I.*

Discontinued after 1916-17. See 31a.

8a. QUANTITATIVE ANALYSIS. *Laboratory.*

(Ingram, Ambler)

This course is offered primarily for students of metallurgy who desire to become acquainted with the methods of analysis of matters, speisses, crude and refined lead and copper bullion, spelter, alloys, and similar material. No required schedule is laid out; students are strongly recommended to employ some of this time in elementary physico-chemical measurements, as this subject has become nearly indispensable in their branch.

Prerequisite: Chemistry 6b.

Required in II., as alternate with 10a.

Junior year, first semester, six hours per week. Credit three hours.

After 1916-17 this course will be discontinued.

9a. ELECTRO-CHEMISTRY. *Lectures.* (Hammond)

The course opens with a brief theoretical introduction to the Nernst theory. The main object of the lectures is the application to the theory of the deposition of metals out of aqueous solutions as practiced in electro-metallurgy.

Prerequisite: Chemistry 7b.

Required in II.

Junior year, first semester, two lectures per week. Credit two hours.

Text: *Manuscript Notes.*

After 1916-17 this course will be discontinued.

10a. ELECTRO-CHEMISTRY. *Laboratory.* (Hammond)

The practical work consists of the measurements of electrolytic conductances and of single differences of potential, followed by experiments on the relation between the electrode potential and current density, and on the electrolytic refining of metals.

Prerequisite: Must be accompanied by Chemistry 9a.

Required in II., as alternate with 8a.

Junior year, first semester, six hours per week. Credit three hours.

Text: *Manuscript Notes.*

After 1916-17 this course will be discontinued.

11a. MEMOIRS. *Classroom Work.* (Gottschalk, Ingram)

Similar to 11b, somewhat more advanced and subjects selected to suit.

Prerequisites: 2b, 21a.

Discontinued after 1916-17.

11b. CHEMICAL MEMOIRS. *Classroom Work.*

(Gottschalk)

Carefully prepared abstracts of current articles or of special subjects are prepared by the student for this course.

Prerequisite: Chemistry 9a.

Required in II.

Junior year, second semester, two hours per week. Credit two hours.

Discontinued after 1916-17.

Elective and Graduate Courses.

15a. ENGINEERING CHEMISTRY. *Lectures.* (Ingram)

There is nothing more essential to the practical engineer of today, no matter in which of the special branches he is working, than an intimate knowledge of the chemistry as well as the mechanics of materials. In this course are taken up in order the chemistry of fuels, industrial waters, lubricants, building materials, lime and cement, paving and wood preservation, paints and varnishes, and explosives.

One hour per week is devoted to reports by the students on topics of interest gleaned from the industrial journals.

Prerequisites: Chemistry 5a, 6a, and 6b.

First semester, three hours per week. Credit three hours.

Text: Benson, *Industrial Chemistry.*

Manuscript Notes.

17a. INDUSTRIAL CHEMISTRY. *Lectures.* (Ingram)

This is essentially an advanced course in Applied Chemistry. As considerable time is spent in the course in General Chemistry in discussing its application in the industries, a certain elementary knowledge of the subject is presupposed.

No attempt is made to burden the student with the usual mass of detail concerning the various standard processes, although a certain amount of textbook work is required. The application of physico-chemical methods to the solution of practical industrial problems is considered of primary importance and receives the maximum amount of attention. The theories underlying the more typical industrial operations are taken up, some time being devoted to discussions on drying, evaporation, crystallization, filtration, heat-transfer, distillation, etc.

The specific industries studied are selected more for the typical operations they involve rather than in an attempt to cover the entire field. The selections may be made from the following, and may vary from year to year. The Acid Industrials, Ammonia and Alkali, Fertilizers, Commercial Chemicals, Distillation of Coal and Wood, Soaps, Oil Industries, Sugar and Glucose, Paper, Industrial Alcohol, Laundering, Textiles and Dyeing, Leather, etc.

Required in VII.

Prerequisites: 23b, 21b, 22b.

This course must be accompanied by Chemistry 16a.

Senior year, first semester, three hours per week. Credit three hours.

Text: Rogers, *Industrial Chemistry.*
Kremann-Potts, *Applications of Physico-Chemical Theory.*
Manuscript Notes.
Reference.

17b. INDUSTRIAL CHEMISTRY. *Lectures.* (Ingram)

A continuation of 16a, together with a consideration of the design, erection and equipment of chemical plants.

Required in VII.

Prerequisite: Chemistry 16a.

Senior year, second semester, two hours per week. Credit two hours.

Text and Reference: Dyson and Clarkson, *Chemical Works, Their Design, Erection and Equipment.*
Manuscript Notes and Blue Prints.

18a. INDUSTRIAL CHEMISTRY. *Plant.* (Ingram, Lane)

This course is designed to accompany the lectures in Industrial Chemistry and to give the student an opportunity to revise his pre-acquired knowledge to fit large-scale operations. It is purposed that the chemical engineers should at this point in their course be required to demonstrate their ability in putting to practical use in the works those principles of chemistry and mechanical and electrical engineering which they may have learned in the more or less preparatory courses.

A detailed description of the plant with all its machinery and accessories cannot be given as yet, since all of the equipment has not been definitely decided on. It is the intention, however, to equip this laboratory as completely as possible with most of the appliances necessary for medium-scale operations. The plant will be arranged to illustrate the methods used in commercial chemical works, and the actual working of each process will be in charge of a superintendent appointed from among the students. This man is to be solely responsible for the success or failure of the work under his direction, and each man in the course must occupy this position in turn. The other students are to be arranged into a working force suitable to the process in hand.

The actual manufacture of some of the materials studied in Chemistry 16a is to be carried out, special attention being paid to yields and cost of manufacture.

During the term 1917-1918 the work will consist of assisting in the erection and testing of the various types of machinery. Full credit will be given for this work.

This course must be accompanied by Chemistry 16a.

Required in VII.

Senior year, first semester, six hours per week. Credit three hours.

Text: Rogers, *Laboratory Guide of Industrial Chemistry.*
Manuscript Notes and Blue Prints.
Reference Works.

18b. INDUSTRIAL CHEMISTRY. *Lectures.* (Ingram)

A continuation of 16a, together with a consideration of the design, erection and equipment of chemical plants.

Prerequisite: Chemistry 16a.

This course must be accompanied by Chemistry 16b.

Senior year, second semester, two hours per week. Credit two hours.

Text and Reference: Dyson and Clarkson, *Chemical Works, Their Design, Erection and Equipment.*
Manuscript Notes and Blue Prints.

21a. ORGANIC CHEMISTRY. *Lectures.* (Hammond)

A study of the compounds of the alphatic series.

Prerequisites: Chemistry 1b, 2b.

Required in VII.

Junior year, first semester, three hours per week. Credit two hours.

Text: Cohen, *Theoretical Organic Chemistry.*

21b. ORGANIC CHEMISTRY. *Lectures.* (Hammond)

A study of the compounds of the aromatic series.

Prerequisites: Chemistry 21a.

Required in VII.

Junior year, second semester, three hours per week.

22a. ORGANIC CHEMISTRY. *Laboratory.* (Hammond)

Preparation and purification of typical alphatic compounds with verification of their constants.

Prerequisites: Must be accompanied by Chemistry 21a.

Required in VII.

Junior year, first semester, six hours a week. Credit three hours.

Text: Cohen, *Practical Organic Chemistry.*

22b. ORGANIC CHEMISTRY. (Hammond)

Preparation and purification of typical aromatic compounds with verification of their constants.

Prerequisites: Accompanies Chemistry 21b.

Required in VII.

Junior year, second semester, six hours a week. Credit three hours.

Text: Cohen, *Practical Organic Chemistry.*

23b. INDUSTRIAL ECONOMICS. *Lectures.* (Ingram)

Before passing on to the consideration of the specific industries, which is taken up in the Senior year, the men are first introduced to some of the economic and administrative problems involved in chemical manufacturing. To begin with, this necessitates a rather extended reading course in Pure Political Economy, which is to serve as a foundation for subsequent application to industrial problems.

While the student is acquiring this economic perspective, the subjects of Business Administration, which includes Accounting Systems, Purchasing, Selling, etc., Patents, Industrial Organization, Professional Ethics, Factory Hygiene and Scientific Management are discussed. The latter part of the course consists of lec-

tures in and reading assignments on the following topics: Effect of Economic Conditions on Location of Chemical Plants, Price and Value of Products, Markets and Transportation, Labor, Legislation relating to the Use and Manufacture of Chemicals, Industrial Insurance, Competition, Exports and Imports and the Exploitation of Chemical Ideas.

Prerequisites: Chemistry.

Required in VII.

Junior year, second semester, three hours per week. Credit three hours.

Texts: *Manuscript Notes.*
Manuscript Translations.
Reference Works.

24b. CHEMICAL ENGINEERING DATA. *Laboratory.*

(Ingram)

To accompany and supplement the work described in Chemistry 23b. To consist mainly of individual research in the collection and compilation of data concerning the administrative as well as the scientific side of Chemical Manufacturing. An attempt is made to gain some insight into the manner in which the office collects, files and interprets the facts and figures furnished by the works. Graphical methods of presentation of the information gathered are studied, and cost, efficiency and valuation curves constructed from data furnished by the industries.

Prerequisite: Chemistry 23b.

Second semester, three hours per week. Credit three hours.

25b. APPLIED ELECTRO-CHEMISTRY. *Lectures.*

(Hammond)

A study of the theories of electrolysis, conductance of electrolytes, electromotive force, polarization.

Prerequisites: Chemistry 18a, 22a. Physics 4a.

Required in II., and VII.

Junior year, second semester, two hours a week. Credit two hours.

26b. APPLIED ELECTRO-CHEMISTRY. *Laboratory.*

(Hammond)

Measurements of conductivity, electromotive force, resistance, single potentials; electro-deposition of metals, electro-analysis.

Prerequisites: Must be accompanied by Chemistry 25b.

Required in II., and VII.

Junior year, second semester, six hours a week. Credit three hours.

29b. SEMINAR. *Classroom Work.* (Gottschalk, Ingram)

Prerequisites: Chemistry 11a, 16a.

Senior year, second semester, two meetings a week. Credit two hours.

31a. ANALYTICAL CHEMISTRY. *Lectures.*

(Gottschalk, Ingram)

This course is designed primarily for Chemical Engineers and those students specializing in Chemistry. The first twelve periods will be devoted to a discussion of Qualitative Analytical methods.

During the remainder of this course the following subjects will be discussed:—The balance, weights, and the process of weighing; simple gravimetric analysis; volumetric instruments, their calibration and use; volumetric analysis, standard solutions, and indicators.

Problems in the calculations of analytical chemistry are also discussed.

Prerequisites: Chemistry 2a and 2b. To be accompanied by Chemistry 32a.

Required in VII.

Sophomore year, first semester, two hours per week. Credit two hours.

Text: A. A. Noyes, *Qualitative Chemical Analysis.*
Manuscript Notes.

32a. ANALYTICAL CHEMISTRY. *Laboratory.*

(Gottschalk, Ingram)

The student will devote the first eighteen laboratory periods to the qualitative separation and detection of the metals.

The application of the principles of Quantitative Analysis as illustrated in the simpler Gravimetric and Volumetric determinations will then be taken up.

It is purposed in this course to lay a broad foundation of analytical principles upon which the student may build up by subsequent practice.

Prerequisites: To be accompanied by Chemistry 31a.

Required in VII.

Sophomore year, first semester, eight hours per week. Credit four hours.

Text: A. A. Noyes, *Qualitative Chemical Analysis.*
Moody, *Quantitative Analysis.*
Manuscript Notes.

32b. QUANTITATIVE ANALYSIS. *Laboratory.*

(Gottschalk)

This is a continuation of course 32a.

Prerequisites: Chemistry 31a and 32a.

Required in VII.

Sophomore year, second semester, nine hours per week. Credit four and one-half hours.

34b. FUEL AND GAS ANALYSIS. *Laboratory.*

A more or less practical course in fuel and gas testing especially adapted to the needs of the Mechanical and Electrical Engineer.

Prerequisite: Chemistry 1b and 2b.

Required in V., and VI.

Sophomore year, second semester, six hours per week. Credit three hours.

Text: Gill, *Engine Room Chemistry.*

35a. PHYSICAL CHEMISTRY. *Lectures.* (Gottschalk)

While some attention is paid to the application of physical methods to chemistry, and the qualitative and quantitative theories of chemical equilibria as given by the phase rule and the mass law, the special stress in this course is laid on the study of the effects of the equilibrium factors on chemical reactions.

Prerequisites: Chemistry 6b or 32b. Physics 3b and 4b. To be accompanied by Chemistry 36a.

Required in II. and VII.

Junior year, first semester, three hours per week. Credit three hours.

Text: *Manuscript Notes.*

36a. PHYSICAL CHEMISTRY. *Laboratory.* (Gottschalk)

Laboratory to accompany Chemistry 35a.

Prerequisites: Same as 35a.

Required in II and VII.

Junior year, first semester, nine hours per week. Credit four and one-half hours.

Second Junior year, first semester, six hours per week. Credit three hours.

Elective and Graduate Courses.

112b. WATER ANALYSIS. *Laboratory.*

This course is designed to meet the wants of engineering students. Sanitary water analysis and boiler water analysis are offered, although students interested in geology may substitute mineral water analysis for some of the work.

Prerequisite: Chemistry 6a.

Elective, second semester, six hours per week. Credit three hours.

113a. THEORETICAL CHEMISTRY. *Lectures.*

(Gottschalk)

The applications of theoretical chemistry to fundamental metallurgical principles are assuming such prominence and leading to such important results that a knowledge of this subject is indispensable to the metallurgical engineer who desires to keep pace with the developments in this field. To meet this demand a course for graduate students is offered, presenting the subject of chemical equilibria from the thermodynamic point of view, including a consideration of the technical applications made by Nernst, Le Chatelier, Haber, von Jueptner and others. The student is expected to do considerable reading of original articles in English, German, and French scientific journals and books.

Prerequisites: Chemistry 9a, Mathematics 15a and 17a, and Physics 5a.

Graduate course, first semester, two lectures per week. Credit two hours.

113b. THEORETICAL CHEMISTRY. *Lectures.*

(Gottschalk)

Continuation of Chemistry 13a.

Second semester, two lectures per week. Credit two hours.

Reference: Nernst, *Theoretical Chemistry.*

114b. ADVANCED CHEMISTRY. *Laboratory.*

(Gottschalk)

This is an advanced course to accompany the lectures in Theoretical Chemistry, and includes the study and measurements of typical chemical equilibria, either as a repetition of classical researches in this field, or preferably on original problems. The equipment for this work includes measuring instruments of the most approved types for high temperature, electro-thermic and physico-chemical work, and special apparatus built in the school shops.

Prerequisite: Must be accompanied by Chemistry 13b.

Second semester, six hours per week. Credit three hours.

120a. ORGANIC ANALYSIS.

A laboratory course in the analysis of commercial products.

Prerequisite: Chemistry 21b and 22b.

Six hours per week. Credit 3 hours.

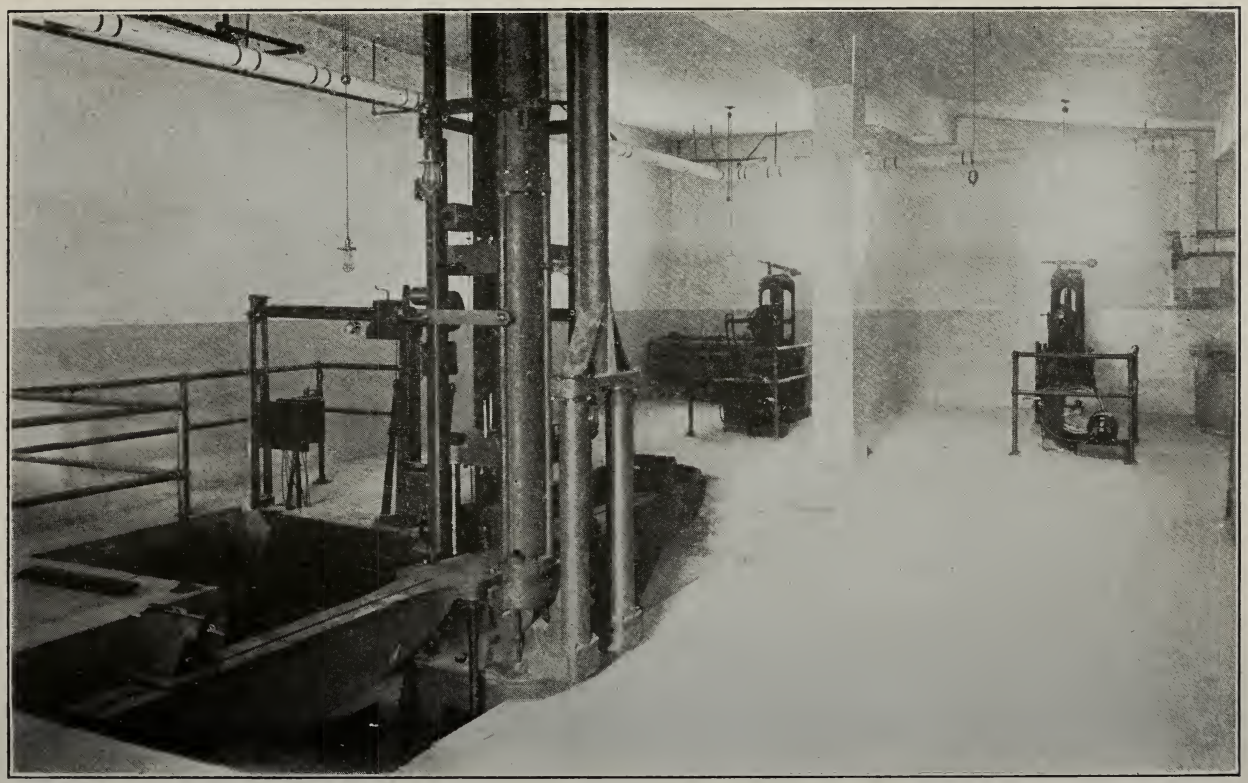
122b. APPLIED ELECTRO-CHEMISTRY.

A laboratory course in the construction, testing and operation of primary and storage cells; preparation of inorganic and organic compounds by means of electrolysis; electroplating.

Prerequisites: 25b and 26b.

Six hours per week. Credit three hours.

CAMPUS VIEW.



TESTING MACHINERY—MATERIALS LABORATORY.

CIVIL ENGINEERING

PROFESSOR HARRIS, ASSISTANT PROFESSOR MCCANDLISS, MR. RISHER, MR. LILLARD, MR. SHRIVER, MR. BARDSLEY, MR. SKEEN.

The Department of Civil Engineering has its lecture rooms, drafting rooms, offices and department library in Norwood Hall. The hydraulics laboratory, and the locker rooms for field equipment, are in the Power Plant Building.

The Laboratory for Testing Materials and the Cement Testing Laboratory, together with office, supply and computation rooms, occupy almost the entire ground floor of Parker Hall.

The plan of study is designed to afford such training, that the graduates will be prepared to perform at once the minor duties in the various branches of the profession. Especial stress is laid upon proficiency in field work, drafting and the design of engineering structures.

For field work the department is equipped with twenty transits, five of which are complete mining instruments with side and top telescopes, and fifteen wye and dumpy levels, representing the principal makes and types of construction. Additional equipment includes a solar compass, a surveyor's compass, three geologist's compasses, four Brunten transits, thirteen plane tables, two sextants, and a liberal supply of hand levels, barometers, clinometers, dip-needles, angle prisms, chains, tapes, level rods, stadia rods, range poles, etc.

The field work is so outlined that the student has an opportunity to judge the relative merits of the various types of field instruments.

An important feature of the instrument room is the locker system. Due to the scope of the equipment it has been possible to arrange in separate lockers complete equipment for each surveying squad.

For the hydrographic field work the department is liberally equipped with current meters, gauges, floats, etc.

The hydrographic field work is not outlined with the regularly catalogued courses but is given as a special course for Seniors in the School of Civil Engineering. The work is usually conducted on the Gasconade river.

The department has at its disposal three well equipped drafting rooms.

The laboratory for testing materials is equipped with one 200,000 pound capacity universal testing machine of the Olsen type, which is capable of testing specimens eight feet long in either tension or compression, and specimens in cross bending 16 ft. long between supports. It also contains two machines, each of 50,000 pound capacity, of the Riehle type, which are used for testing small specimens in tension, compression and cross-bending; one 60,000 inch-pound capacity torsion machine of the Olsen type, and one machine used for demonstration of the action of levers, and for testing small specimens in cross bendings. All machines in this laboratory are direct connected motor driven. The necessary small equipment, such as extensometers, compressometers, etc., is ample for the needs of the classes, and comprises only the most modern types of instruments.

This laboratory affords facilities for: Research in the design and the methods of failure of structures, the study of the physical characteristics and composition of materials, and the determination of the laws controlling the behavior of stressed and unstressed members.

The cement testing laboratory is equipped for making complete physical tests of cement, concrete and concrete aggregates, and for investigations of the proper proportioning of concrete. The equipment consists of two standard tension testing machines; two Vicat apparatus; several specific gravity apparatus; one electric drying oven; one standard steamer; an autoclave; a moist closet; apparatus for determination of specific gravity of, and voids in, concrete aggregate; several sets of standard sieves; standard cylindrical molds for concrete; and an ample supply of standard tension briquette molds, graduates, trowels, spatulas and other small apparatus.

Courses.

2a. SURVEYING. *Plane Surveying.*
(McCandliss, Risher, Bardsley, Shriver)

A general course in surveying, including the adjustments, uses, and limitations of transits, levels, and the minor instruments. Students are drilled in traversing, computing areas, establishing meridians, topographic methods, triangulating, and leveling.

The field work is conducted on and about the campus, the work being referenced to stations of a triangulation system, the bearings and lengths of the sides of which have been accurately determined, thus affording a check on the student work.

Prerequisites: Mathematics 1a, 3a.

Required in I., III., V., and VI.

Sophomore year, first semester, three afternoons per week. Credit five hours.

Texts: Tracy, *Plane Surveying.*

In 1917-18 this course will be two afternoons per week.

4a. ENGINEERING DETAILS. *Laboratory.*

(McCandliss)

This course is designed to represent the conditions of office and drafting room. Especial stress is laid on neatness, accuracy and dispatch. The course covers practice in free-hand lettering for titles, etc., topographical signs, platting of topographical maps, and the drafting of engineering structures.

Prerequisites: To accompany 2a.

Required in III.

Sophomore year, first semester, two afternoons per week. Credit three hours.

3b. SURVEYING. *Higher Surveying.*

(McCandliss, Lillard, Skeen)

A course embracing descriptive astronomy, with special attention to the determination of azimuth, altitude, latitude, longitude and time; and the theory of base line measurements, precise triangulation, and topography.

Field work and problems are given to accompany the lectures, including the execution of a complete topographic survey and map of a small area; in this work an effort is made to familiarize the students with the various instruments and methods used in topographic surveying.

Prerequisite: Civil Engineering 2a.

Required in III.

Sophomore year, second semester, four afternoons per week. Credit six units.

7a. SURVEYING. *Railroad Surveying. Lectures and Problems.*

(McCandliss)

This course treats of the theory, and the practice of surveying, appertaining to the location, construction and maintenance of railroads.

The scope of the work is designed to acquaint the student, in lectures, with the theory of simple, compound, and reversed curves, frogs, switches, turnouts and cross-overs. In the afternoon period the student is drilled in the solution of problems.

Prerequisite: Civil Engineering 2a.

Required in I and III.

Junior year, first semester, one lecture hour and one afternoon per week. Credit three and one-half hours.

Text: Webb, *Railroad Construction.*

7b. SURVEYING. *Railroad Construction.* (McCandliss)

This course is intended to extend the scope of Civil Engineering 7a, and treats of the theory of spirals, earthwork, haul, overhaul and estimates.

Prerequisite: Civil Engineering 7a.

Required in III.

Junior year, second semester, two lecture hours per week. Credit two hours.

9b. HYDRAULICS. *Lectures and Problems.* (Harris)

The theory of hydrostatics and of hydraulics and application to the dependent problems in engineering practice, such as the determination of empirical coefficients and their application in determining the flow of water through orifices, weirs, pipes, canals, and rivers. Also the theory of hydraulic motors and dynamic pumps and the practice with such machines.

Prerequisite: Mathematics 15a.

Required in I., II. and III.

Junior year, second semester, three hours per week. Lectures and one afternoon for solution of problems.

Credit 4.5 hours.

Text: Merriman, *Hydraulics.*

11a. MASONRY CONSTRUCTION. *Foundations. Lectures.* (McCandliss)

The object of this course is to set forth in lectures the principles governing the design of the foundations of engineering structures. The economics of building materials, and the treatment of ordinary and pile foundations and cofferdams are successively considered. The theory of spread foundations, gravity dams, retaining walls, piers, abutments, stacks, etc., are discussed.

Prerequisites: Mathematics 15a, to be accompanied by Mathematics 19b.

Required in III.

Junior year, first semester, two lectures per week. Credit two hours.

Text: Baker, *Masonry Construction.*

11b. MASONRY CONSTRUCTION. *Beams and Arches. Lectures and Problems.* (McCandliss)

This course is a continuation of Civil Engineering 11a. The scope of the lectures is intended to cover the application of the law of mechanics to design of the more complicated members of engineering structures. A theoretical study of beams under the vary-

ing conditions of loading is made, with especial consideration of the behavior of reinforced concrete and its application to design. The latter part of the semester work is devoted to the theory of arches. The afternoon periods are taken up with the solution of problems in design and in the preparation of the details of such engineering structures as are covered in the lectures.

Prerequisites: Civil Engineering 12a.

Required in III.

Junior year, second semester, two lectures and one afternoon per week. Credit 3.5 hours.

Texts: Baker, *Masonry Construction.*
Hool, *Reinforced Concrete Construction.*

13b. ROADS AND PAVEMENTS. *Lectures.* (Lillard)

This course is intended to treat of the economic properties of road materials; the location, construction and maintenance of roads and streets; types of improvements, their designs and estimates of costs.

A special feature of this course is the Seminar work, which is conducted one hour each week. Throughout the year each member of the class is required to prepare and present to the class papers on some assigned subject relative to roads and road practice.

Prerequisite: Civil Engineering 2a.

Required in III.

Junior year, second semester. Three hours per week. Credit three hours.

15a. FRAMED STRUCTURES. *Lectures and Problems.* (Harris)

Treats of general methods of determining stresses in such structures as simple-span bridges, roofs, towers, three-hinged arches, etc., and of the design of individual members, such as beams, posts, and rods, to carry the determined stress.

Prerequisite: Mathematics 17b.

Required in III.

Senior year, first semester, two lectures per week and one afternoon per week. Credit three and a half hours.

15b. STRESSES. *Lectures and Problems.* (McCandliss)

This course is outlined to include both graphical and analytical solution of stresses occurring in derricks, stacks, simple bridges and roof trusses. Stresses in beams and trusses of single and multiple systems are determined under the action of static, rolling, concentrated and prescribed wheel loads. Stresses in roofs under action of static or wind loads are also considered.

Prerequisites: Mathematics 15a, 17a and 19b.

Required in III.

Junior year, second semester, two lectures and two afternoons per week. Credit 5 hours.

17b. CONTRACTS. *Lectures.* (Harris)

A lecture course in the law of contracts, and the preparation of specifications.

Prerequisites: Completion of the Junior course.

Required in III.

Senior year, second semester, one hour per week. Credit one hour.

Text: Tucker, *Contracts in Engineering.*

19a. WATER SUPPLY. *Lectures.* (Harris)

Covers the selection, storing, transporting, purification, and delivering water to cities and towns.

Prerequisites: Civil Engineering 9b and 11b.

Required in III.

Senior year, first semester, five hours per week. Credit five hours.

Text: Turneaure and Russell, *Water Supply.*

After 1916-17 this course will be three hours per week.

20a. MATERIAL TESTING LABORATORIES.

(McCandliss, Risher)

In this course the student's time is divided between the cement testing laboratory and the laboratory for testing materials. Early in the semester the work consists of making complete physical tests of standard brands of natural and Portland cements, and the effects of such adulterants as free lime, sulphur acids and alkalies upon the strength and durability of the same. The laws governing the proportionment of concretes, and mortars, are verified experimentally.

Tests are conducted to show the relationship of strength to density in mortars and concrete; the effect of fineness of grinding of a cement to its setting properties; the effect of clay upon the strength and density of concrete; the effect of commercial waterproofing ingredients upon the porosity of concrete, and such other determinations as are appropriate to a laboratory of this character. The entire course is designed to impress the student with economic truths, the adaptability and the limitations of the use of mortars and concretes for materials of engineering construction.

The latter part of the semester is devoted to the physical tests in tension, compression, flexure and torsion of such materials as iron, steel, timber, stone, brick and other clay products; the study of the behavior of these materials under stress and the interpretation of the results of the investigations.

Prerequisite: Mathematics 15a.

Required in III.

Junior year, first semester, two afternoons per week. Credit three hours.

20b. MATERIALS TESTING LABORATORIES.

(McCandliss, Lillard)

The character of the work done in this course is essentially the same as that of Engineering Laboratories 20a, except that only one-half as much time is devoted to the work, necessitating fewer experiments and a more limited scope.

The major portion of the time is taken up with the physical tests of iron, steel, and timber, in tension, compression, cross-bending, and torsion; the study of the behavior of these materials when subjected to stress; the interpretation of the results of the tests, and the reports upon the same.

The work in the cement testing laboratory consists of a few exercises in the physical testing of natural and portland cements. (This course is not to be substituted for Engineering Laboratory 20a.)

Prerequisite: Mathematics 15a.

Required in I.

Junior year, second semester, one afternoon per week. Credit one and one-half hours.

21a. IRRIGATION ENGINEERING AND RIVER AND HARBOR IMPROVEMENTS. *Lectures.* (Harris)

The time here allotted is given to the study of special problems arising in the design of irrigation projects, such as location of the main canal and its head works, mapping the lands, locating the secondary canals, special methods of measuring and delivering the water, necessary water consumption, etc., and to the study of the cause and control of foods, protection of river banks, improvements of navigation, and protection and improvement of harbors.

Prerequisites: Civil Engineering 9b and 11b.

Elective.

Senior year, first semester, three hours per week. Credit three hours.

23a. RAILWAY ECONOMICS. *Lectures.* (McCandliss)

This course treats of the economic principles, of the location, revision, operation and finance of railroads.

The scope of the work covers train resistances under varying conditions of traffic, grade and curvature; locomotive performance; valuation of railway properties, estimates, etc. An important feature in this course is the assigned outside reading and reports on appropriate topics.

Prerequisite: Civil Engineering 7a.

Elective.

Senior year, first semester, three hours per week. Credit three hours.

Text: Webb, *Economics of Railway Construction.*

25b. STRUCTURAL DESIGN (Higher Structures). *Lectures.* (Harris)

Covers the study of effects of concentrated wheel loads on simple bridges and the study of cantilever, swing and suspension bridges and elastic arches.

Prerequisites: Civil Engineering 15a and 15b.

Required in III.

Senior year, second semester, five hours per week. Credit five hours.

Text: Kirkham, *Structural Engineering.*

After 1916-17 this course will be three lectures and nine hours per week laboratory.

27a. COMPRESSED AIR. *Lectures and Problems.* (Harris)

This course covers the theory of air compression, both in reciprocating machines and in centrifugal machines; also the measurement and transmission of air, and its application to the industries.

The problems include laboratory work in testing compressors and fans, determination of friction in pipes, flow through orifices, etc., and the solution of problems, such as come up in practice.

Prerequisites: Civil Engineering 9b, Mathematics 17b, and Physics 5a.

Elective.

Senior year, first semester, two lectures per week and one afternoon for laboratory and problems. Credit three and one-half hours.

Text: Harris, *Compressed Air.*

29b. SANITARY ENGINEERING. *Lectures.* (McCandliss)

Treats of the precautions necessary to protect water supplies from pollution and the methods available for purification of sewage. Also the construction of sewer systems for the collection and transportation of sewage and storm waters.

Prerequisite: Civil Engineering 19a.

Required in III.

Senior year, second semester, five hours per week. Credit five hours.

Text: Followell, *Sewage of Cities.*

31a. MASONRY DESIGN. *Lectures and Laboratory.*

(Harris)

This course is continued from Civil Engineering 11b. It includes the complete design of such structures as high masonry dams, concrete-steel arches, and concrete-steel dams.

Prerequisite: Civil Engineering 11b.

Required in III.

Senior year, first semester, three lectures, and two afternoons per week. Credit six hours.

ENGLISH AND MODERN FOREIGN LANGUAGES

Professor Barley, Assistant Professor Daniels, Mr. Hutsinpillar.
Mr. Walsh, Mr. Zoller, Assistants.

ENGLISH.

1a. RHETORIC AND COMPOSITION. *Lectures.*

(Hutsinpillar)

A study of the theory of exposition, with especial attention to the paragraph and to the correct and the effective sentence. A reasonable amount of written work is required of the student in order that he may gain facility in the use of clear, idiomatic English. In many instances, this written work is drawn from other courses pursued by the student, thereby correlating his practice in composition with his immediate interests and activities. There is also given weekly practice in oral composition.

Prerequisites: College entrance requirements in English.

Required in all courses.

Freshman year, first semester, three hours a week. Credit three hours.

Text: Linn, *Essentials of English Composition.*

1b. RHETORIC AND COMPOSITION. *Lectures.*

(Hutsinpillar)

This course is a continuation of 1a. Attention is given to the theory of punctuation and to the writing of long themes. Some outside reading is required.

Prerequisite: 1a.

Required in all courses.

Freshman year, second semester, three hours a week. Credit three hours.

Text: Wooley, *Mechanics of Writing.*

3a. ENGLISH PROSE. *Lectures.* (Barley)

A reading course in selected standard English and American prose of the nineteenth century and of the present day.

Prerequisites: English 1a and 1b.
Required in all courses.
Sophomore year, first semester, three hours a week. Credit three hours.

3b. ENGLISH PROSE. *Lectures.* (Barley)

A continuation of 3a.
Prerequisites: As in 3a, and 21a.
Required in all courses.
Sophomore year, second semester, two hours a week. Credit two hours.

21a. ADVANCED COMPOSITION.

A course for those students in English 3a or 3b who are deficient in English composition and for any others who are referred to the Department as in need of additional training in this work.
Second semester, two hours a week. No credit.

5a. SHAKESPEARE. *Lectures.* (Barley)

Five or six of Shakespeare's plays are carefully studied in class and several more are required as collateral reading.
Prerequisites: English 3a and 3b.
Required in Curriculum IV.
Junior year, first semester, three hours a week. Credit three hours.

5b. CONTEMPORARY DRAMA. *Lectures.* (Barley)

A reading course in the drama of the present day, supplemented by lectures.
Prerequisites: English 3a and 3b.
Required in Curriculum IV.
Junior year, second semester, three hours a week. Credit three hours.
Text: Dickinson, *Chief Contemporary Dramatists.*

19a. ENGINEERING WRITING. *Lectures.* (Barley)

An advanced course in oral and written technical reports, and in the details and problems of engineering writing.
Senior year, first semester, two hours a week. Elective.
Credit two hours.

MODERN FOREIGN LANGUAGES.

Students in Curriculum I are required to complete one year's work in German, or French, or Spanish, and those having completed Elementary Spanish may elect a second year's work in this language; those in Curricula II and VI must complete one year's work in German, or French, or Spanish, and may elect an additional year's work in the language already pursued; those in Curricula III and V must complete two years' work in German, or French, or Spanish; those in Curricula IV and VII must complete two years' work in German or French.

No advanced standing will be given for high school credits in language except by examination.

At present the United States Geological Survey requires French or German in its civil service examinations. Students who expect to qualify for this work are advised to elect one or both of these languages.

Students who expect to engage in work in Central America or South America are advised to elect Spanish.

7a. ELEMENTARY GERMAN. *Lectures.* (Daniels)

Open to all Freshmen.

Freshman year, first semester, three hours a week. Credit three hours.

Text: Thomas, *Practical German Grammar*, to be supplemented by easy reading as soon as practicable.

7b. ELEMENTARY GERMAN. *Lectures.* (Daniels)

Prerequisites: German 7a.

Freshman year, second semester, three hours a week. Credit three hours.

Texts: Thomas, *Practical German Grammar.*
Thomas and Hervey, *German Reader.*

9a. SCIENTIFIC GERMAN.

Prerequisites: German 7a and 7b.

Sophomore year, first semester, three hours a week. Credit three hours.

Text: Kip, *Scientific German Reader.*

(Not offered in 1916-1917.)

9b. RESEARCH GERMAN.

Prerequisites: German 9a.

Sophomore year, second semester, two hours a week. Credit two hours.

Texts: Assigned articles in scientific textbooks and periodicals.

(Not offered in 1916-1917.)

11a. ELEMENTARY FRENCH.

Open to all Freshmen.

Freshman year, first semester, three hours a week. Credit three hours.

Text: Fraser and Squair, *French Grammar*, to be supplemented by easy reading as soon as practicable.

(Not offered in 1916-1917.)

11b. ELEMENTARY FRENCH.

Prerequisite: French 11a.

Freshman year, second semester, three hours a week. Credit three hours.

Texts: Fraser and Squair, *French Grammar.*
Easy stories and plays.

(Not offered in 1916-1917.)

13a. SCIENTIFIC FRENCH. *Lectures.* (Daniels)

Prerequisites: French 11a and 11b.

Sophomore year, first semester, three hours a week. Credit three hours.

Text: Daniels, *French Scientific Reader.*

13b. RESEARCH FRENCH. *Lectures.* (Daniels)

Prerequisites: French 13a.

Sophomore year, second semester, two hours a week. Credit two hours.

Texts: Assigned articles in scientific textbooks and periodicals.

15a. ELEMENTARY SPANISH. *Lectures.* (Daniels)

Open to all Freshmen except those in Curricula IV and VII.

Freshman year, first semester, three hours a week. Credit three hours.

Text: Hills and Ford, *Spanish Grammar.*

15b. ELEMENTARY SPANISH. *Lectures.* (Daniels)

Prerequisites: Spanish 15a.

Freshman year, second semester, three hours a week. Credit three hours.

Texts: Hills and Ford, *Spanish Grammar.*
Harrison, *Spanish Commercial Reader.*

17a. COMMERCIAL SPANISH. *Lectures.* (Daniels)

Prerequisites: Spanish 15a and 15b.

Sophomore year, first semester, three hours a week. Credit three hours.

Text: Ernesto Nelson, *The Spanish American Reader.*

17b. CONVERSATIONAL SPANISH. *Lectures.* (Daniels)

Prerequisites: Spanish 17a.

Sophomore year, second semester, two hours a week. Credit two hours.

Texts: Ernesto Nelson, *The Spanish American Reader.*
Hall, *All Spanish Method, First Book.*

GEOLOGY AND MINERALOGY

Professor Cox,* Assistant Professor Dake, Mr. Muilenburg, Mr. Kemp, Mr. Brown, Mr. Bock, Mr. Lucky.

Equipment.

The geological and mineralogical laboratories are on the second floor of Norwood Hall. They are supplied with suitable tables for the examination of rocks and minerals. The equipment of the department includes reference, working, and cabinet collections of minerals, ores, rocks, and fossils and many specimens illustrating metallurgical processes; a working collection of wooden and glass crystal models and natural crystals; full sets of maps and reports and a set of geological relief models.

There is also a collection of thirty-five hundred specimens representing the mineral wealth of Missouri, consisting of coal, clays of many sorts, building stones, and ores of lead, zinc, iron, and copper. The minerals occurring as gangue with the metalliferous deposits of the State are also well represented. There is also a complete collection of the economic minerals of Missouri and a good economic geological collection representing the world at large. This collection was a part of the Missouri Mineral Exhibit displayed at the World's Fair at Chicago and was presented to the School of Mines and Metallurgy by the General Assembly in 1895.

In addition to the above-mentioned collection the State Board of Equalization assigned to the School the specimens, models, maps, and machinery which constituted the Missouri Mining Exhibit at the St. Louis Exposition, thus giving to the School a large amount of valuable equipment.

The Museums contain crystals and minerals from various parts of the world, the important mining districts of the State of Missouri being especially well represented by the economic collection from Southwestern Missouri, the great geological relief map, polished stone tables and ornamental stones, and other complete collections of the Missouri Building of the St. Louis Exposition.

Rock-breaking and section machines, instruments for geological surveys, petrographic microscopes, thin mineral and rock sections, and lantern slides are included in the equipment of this department.

*On leave of absence, 1916-17.

1a. MINERALOGY. *Lectures and Laboratory.*

(Muilenburg, Kemp, Brown and Bock)

Elementary crystallography, including the study of models and natural crystals, with oral and written recitations, eleven weeks; practice in blowpipe analysis with determination of unknowns, four weeks; introduction to descriptive and determinative mineralogy the remainder of the semester.

Prerequisites: Chemistry 1b, 3b and 4b.

Required in I., II. and IV.

Sophomore year, first semester, two hours' lectures and six hours' laboratory per week. Credit five hours. In 1917-18 this course will be reduced to one lecture and three hours' laboratory. Credit two and one-half hours.

Texts: Patton, *Lecture Notes on Crystallography.*
Butler, *Handbook of Blowpipe Analysis.*
Dana, *Textbook of Mineralogy.*

1b. MINERALOGY. *Lectures and Laboratory.*

(Muilenburg, Kemp, Bock and Lucky)

Descriptive and determinative mineralogy. A study of the fundamental principles of classification and the distinctive characteristics of minerals with a thorough drill in the recognition of about two hundred species.

Prerequisite: Mineralogy 1a.

Required in I., II., also in IV. with geology major.

Sophomore year, second semester, two hours' lectures and six hours' laboratory per week. Credit five hours. In 1917-18 this course will be reduced to one lecture and six hours laboratory. Credit four hours.

2a. C. E. MINERALOGY. *Lectures and Laboratory.* (Kemp)

A study of the common ore and rock-forming minerals and types of rocks. The necessary lectures are given during the regular laboratory periods. This course is intended for the Civil, Mechanical, Electrical, and Chemical Engineering students, the same ground being covered more thoroughly by Courses 1a, 1b and 5a, so that full credit may not be given for it and one or more of these courses, and it may not be substituted for any part of them.

Prerequisite: Chemistry 1b.

Required in III., V., VI. and VII.

Sophomore year, first semester, three hours per week. Credit one and one-half hours.

11a. OPTICAL MINERALOGY. (See Geology 11a.)

GEOLOGY.

Courses.

3a. GENERAL GEOLOGY. *Lectures.* (Dake, Kemp)

Dynamic geology. A somewhat detailed account of geologic processes. The larger topics are treated more exhaustively than in the required text. Local field trips.

Prerequisites: Either 2a or 1a and 1b.

Required in I., III., and in IV. with geology major.

Junior year, first semester, four hours per week. Credit four hours. The course will be reduced to three hours in 1917-18.

Text: Scott, *An Introduction to Geology.*

3b. GENERAL GEOLOGY. *Lectures.* (Dake, Kemp)

Introductory structural and historical geology. Typical geologic structures and their effects upon the physiographic development of the earth's surface are considered for the first eight weeks. Geologic history is then traced from the beginning of the record to the present, as much attention as possible being paid to the rock systems and their contained fossils, with some reference to geographic changes and organic evolution.

Prerequisites: Geology 3a. To be accompanied by Geology 4b.

Required in I., III., and in IV. with geology major.

Junior year, second semester, four hours per week. Credit four hours. The course will be reduced to three hours in 1917-18.

Text: Scott, *An Introduction to Geology.*

4b. GENERAL GEOLOGY. *Laboratory.*

(Dake, Kemp, Brown)

Laboratory exercises in reading topographic and geologic maps; in the construction of profile and geologic sections and simple geologic maps. These exercises are designed to illustrate the subject-matter of the earlier lectures of Course 3b, and occupy nine weeks; excursions and field practice in elementary geologic mapping the remainder of the semester.

Prerequisite: Geology 3a. To accompany Geology 3b.

Required in I., III., and IV. with geology major.

Junior year, second semester, six hours per week. Credit three hours.

References: Hayes, *Handbook for Field Geologists.*
Geikie, *Outlines of Field Geology.*
Prof. Paper, *U. S. Geol. Survey No. 60.*

5b. LITHOLOGY. *Lectures and Laboratory.*

(Muilenburg, Kemp, Brown)

A study of the structure, texture, mineral and chemical composition, and the manner of formation and occurrences of igneous, sedimentary, and metamorphic rocks. This course is adequate for all general field determinations.

Prerequisites: Mineralogy 1a and 1b, to be accompanied by Geology 3b.

Required in I., and in IV. with geology major.

Junior year, second semester, one hour lecture and three hours' laboratory per week. Credit two and one-half hours.

Text: Kemp, *Handbook of Rocks.*

7a. GEOLOGY OF THE UNITED STATES. *Lectures.*

(Dake)

The physiography, stratigraphy, economic products, and geologic structure and history of the chief geologic divisions of the United States are summarized in the lectures.

Prerequisites: Geology 3b, 4b, and either 2a or 5b.

Required in IV. with geology major.

Senior year, first semester, three hours per week. Credit three hours.

Text: Blackwelder, *Handbook of Regional Geology: the United States.*

Omitted in 1916-1917.

9a. ECONOMIC GEOLOGY. *Lectures.* (Dake)

A study of the origin, occurrence, and distribution of the metallic ores. Various type deposits of the world are considered, special attention being given to those of the United States. Written reports are required for each district studied; reference always being made to the original reports, thus familiarizing the student with the various technical publications and their usage. The ores of the following metals are considered: zinc, lead, copper, gold, silver, nickel, cobalt, iron, manganese, tin, mercury, tungsten, platinum, and aluminum. Trips to local points of interest.

Candidates for the degree of Bachelor of Science in Mine Engineering or Metallurgy taking this course must also take the geology part of the Course 12, Senior Trip.

Prerequisites: Geology 3b, 4b, and either 2a or 5b.

Required in I. with general mining or geology options, and in IV. with geology major.

Senior year, first semester, five hours per week. Credit five hours. The course will be reduced to four hours in 1917-18.

Text: No text required. Reference largely to reports by the United States and State geological surveys.

9b. ECONOMIC GEOLOGY. *Lectures.* (Muilenburg)

A study of the origin, occurrence, and distribution of the economic deposits of the non-metals. Reference is made to those technical reports which describe the most important deposits, and a written summary is required for each district studied. The subjects covered are as follows: coal, oil and gas, clays, cements, gypsum, salt, sulphur, sulphides, building stone, abrasives, gems, soils, and fertilizers. Trips to local points of interest.

Students taking this course who do not take Course 12 will be given special work while the remainder of the class is taking the Senior Trip.

Prerequisites: Geology 3b, 4b, and either 2a or 5b.

Required in I. with Geology option, and in IV. with Geology major.

Senior year, second semester, three hours per week. Credit three hours.

Text: No text required. Reference largely to reports of the United States and State geological surveys.

11a. PETROGRAPHY. *Lectures and Laboratory.*

(Muilenburg)

The semester is devoted to the study of optics as applied to the determination of minerals by the polarizing microscope, the identification of minerals in thin sections, and the grinding of rock and mineral thin sections.

Prerequisites: Geology 3b, 4b, and 5b, and Physics 3b and 4b.

Senior year, first semester, three hours' lecture and nine hours' laboratory per week. Credit seven and one-half hours.

Text: Luquer, *Minerals in Rock Sections.*

11b. PETROGRAPHY. *Lectures and Laboratory.*

(Muilenburg)

A study of nomenclature, relations and alterations of rocks together with the petrographic analysis and the recalculation of the chemical analysis of rocks.

Prerequisite: Geology 11a.

Senior year, second semester, three hours' lecture and six hours' laboratory per week. Credit six hours.

Texts: Kemp, *Handbook of Rocks*, with one of the following:
Iddings, *Rock Minerals.*
Winchell, *Elements of Optical Mineralogy.*
Johannson, *Determination of Rock-Forming Minerals.*

12. SENIOR TRIP. (Dake)

During the second semester of the Senior year a three weeks' trip is taken to Joplin, St. Louis, Flat River, and other points in the Southeastern Missouri Lead District, for the purpose of studying Mining, Ore Dressing, Smelting, Geology, and Power Plants of these districts. The geology portion of these trips is required of all candidates for the degrees in Mining Engineering and Metallurgy who have taken Course 9a.

Prerequisite: Geology 9a.

Senior year, second semester.

13b. STRUCTURAL GEOLOGY. *Lectures.* (Dake)

An advanced course in the study of rock deformation, including a review of the theories of the origin of the earth; a discussion of the zones of rock fracture and rock flowage; a classification and discussion of cleavage, joints, faults, folds, autoclastic rocks, conglomerates, and pseudo-conglomerates; and a consideration of mountain-building forces, together with the horizontal and vertical depth affected, with application to special districts.

Prerequisites: Geology 3b, 4b, and either 2a or 5b.

Required in I. with geology option and in IV. with geology major.

Senior year, second semester, three hours per week. Credit three hours.

14a. FIELD GEOLOGY. *Field Work.* (Dake)

The course consists of both field and laboratory work, the two being varied to suit the weather. The field work consists of the making of topographic and geologic maps, with suitable sections and reports, of assigned areas. The laboratory work includes the making of sections and maps and the final drafting of the field work.

Prerequisites: Geology 3b, 4b, and either 2a or 5b.

Required in I. with geology option and in IV. with geology major.

Senior year, first semester, six hours per week. Credit three hours.

15b. GEOLOGY CONFERENCE. (Dake)

The conference consists of a discussion by the students and instructors of geologic problems and literature, each student being assigned certain work upon which he must report to the class.

Prerequisite: Geology 9a.

Senior year, second semester, one hour per week. Credit one hour.

16b. ADVANCED GEOLOGY. *Laboratory.* (Dake)

An advanced course in the study and interpretation of topographic and geologic maps.

Prerequisites: Geology 3b and 4b.

Required in IV. with geology major.

Senior year, second semester, nine lectures and ninety hours laboratory work for the semester. Credit three hours.

17a. OIL AND GAS. *Lectures.*

A detailed study of the origin and occurrence of the various oil and gas deposits.

Prerequisites: Mineralogy 1b or 2a and Geology 3b.

Senior year, first semester, one hour a week. Credit one hour.

Omitted in 1916-17.

17b. OIL AND GAS. *Lectures.*

Oil drilling, testing and refining.

Prerequisite: Geology 17a.

Senior year, second semester, one hour a week. Credit one hour.

Omitted in 1916-17.

18b. OIL AND GAS. *Laboratory.*

Laboratory work in the study of field maps and the testing of oils.

Prerequisites: Must be accompanied by Geology 17b and 4b.

Senior year, second semester, three hours a week. Credit 1.5 hours.

Omitted in 1916-17.

38. JUNIOR TRIP.

At the end of the school year the members of the Junior class make a three weeks' trip to Colorado and Utah, or other mining districts. The purpose of the trip is to give an opportunity for the study of the geology, mining, and concentration of ores in the districts visited.

Credit may also be obtained for this trip in the following manner:

The student may obtain employment at any mine, mill, or smelter of his own selection, for a period of not less than six weeks. This work will be accepted as a substitute for the regular trip only when accompanied by a suitable report on the mining, metallurgy, and geology of the district in which he is employed. Outlines of these reports will be furnished by the various departments. Affidavits will be furnished the students to be signed by the mine or

mill officials, by whom he was employed, stating the time of such employment and nature of the work.

Credit will be given for this course only to candidates for degrees of B. S. in Mining and Metallurgy.

Prerequisites: Mining 5b, Geology 3b and 4b, and Metallurgy 31b.

Junior year, Summer session. Credit (geology portion) 2 hours toward Senior electives in I. and II.

MATHEMATICS

PROFESSOR DEAN, MR. HINSCH.

While the utility of mathematical study as a mental discipline is duly recognized, the ultimate intention of the student is kept in mind, and the matter and methods of the courses are adjusted, as nearly as possible, to meet the demands of subsequent studies and professional practice.

Courses.

1a. COLLEGE ALGEBRA. *Lectures.* (Hinsch)

Theory of limits, logarithms, progressions, binomial theorem, undetermined coefficients, series and solution of higher equations. Special attention is paid to graphical solutions and practical applications.

Prerequisites: Entrance requirements.

Required in I., II., III., IV., V., VI. and VII.

Freshman year, three hours per week, first semester. Credit three hours.

Text: Hall and Knight, *College Algebra.*

3a. PLANE TRIGONOMETRY. *Lectures.* (Hinsch)

Solution of plane triangles, reduction and transformation of trigonometric expressions, solution of trigonometric equations.

Prerequisite: Mathematics 1a.

Required in I., II., III., IV., V., VI. and VII.

Freshman year, first semester, two hours per week. Credit two hours.

Text: Taylor and Puryear, *Trigonometry.*

5b. SPHERICAL TRIGONOMETRY. *Lectures.* (Hinsch)

Continuation of Mathematics 3a, taking up more difficult parts of analytical trigonometry, solution of spherical triangles, and simpler problems of spherical astronomy.

Prerequisite: Mathematics 3a.

Required in I., II., III., IV., V., VI. and VII.

Freshman year, second semester, two hours per week. Credit two hours.

Text: Taylor and Puryear, *Trigonometry.*

7b. ANALYTICAL GEOMETRY. *Lectures.* (Hinsch)

The object of this course is to familiarize the student with methods rather than with any particular set of curves. Special attention, however, is given to those forms of the equations of the conic sections which occur in technical literature.

Prerequisite: Mathematics 5b.

Required in I., II., III., IV., V., VI. and VII.

Freshman year, second semester, three hours per week. Credit three hours.

Text: Smith and Granville, *Elementary Analysis.*

9a. DIFFERENTIAL CALCULUS. *Lectures.* (Dean)

The student is thoroughly drilled in the derivation of formula, and the application of derivatives in the solution of problems in maxima and minima, in curve tracing, velocity, and acceleration, expansion of functions.

Prerequisite: Mathematics 7b.

Required in I., II., III., IV., V., VI. and VII.

Sophomore year, first twelve weeks of first semester, four hours per week. Credit three hours.

Text: Granville, *Calculus.*
Notes by Professor.

11a, 11b. INTEGRAL CALCULUS. *Lectures.* (Dean)

The student is drilled in the integration of forms occurring in mechanics and physics, in evaluating areas, moments, moments of inertia, in finding centers of gravity, center of stress, and in the derivation and application of fundamental formulæ of hydrostatics and hydraulics.

Prerequisite: Mathematics 9a.

Required in I., II., III., V., VI. and VII.

Sophomore year, five hours per week, after 9a, and first twelve weeks of second semester. Credit one hour on each semester.

Text: Granville, *Calculus.*
Notes by Professor.

13b. DIFFERENTIAL EQUATIONS. (Dean)

Integral forms of the differential equations of mechanics and physics, applications of partial differentiation and partial integration, theory of attraction, dynamics of a particle, and thermodynamics of perfect gases.

Prerequisites: Mathematics 11a and 11b.

Required in I., II., III., V., VI. and VII.

Sophomore year, second semester, five hours per week after 11b. Credit three hours.

Texts: Granville, *Calculus.*
Notes by Professor.

31a. THE THEORY OF STRUCTURES. *Lectures.* (Dean)

The purpose of this course is to present in a thorough and logical manner the fundamental theories upon which the design of all structures is based and to illustrate their application by numerous examples. No attempt is made to treat of the design of complete structures, but the design of the more important elements of which all structures are composed is fully considered. Senior elective, three lecture hours per week. Credit three hours.

Prerequisites: Mathematics 1a to 13b, and Mechanics 17b to 19a.

Text: Spofford, *The Theory of Structures*, Chapters I., II., III., IV., V., VI. and VII., supplemented by lectures and notes.

31b. THE THEORY OF STRUCTURES. *Lectures.* (Dean)

Continuation of 31a. Credit three hours.

Text: Spofford, *The Theory of Structures*, Chapters VIII.-XX., inclusive, supplemented by lectures and notes.

33a. APPLIED MECHANICS. *Lectures.* (Dean)

This course is intended to give that general knowledge of the mechanics of structures and machines which should accompany the detailed study of any special branch of engineering. It will include the following subjects:

Statics of Structures, Kinematics of Machines, Dynamics of Machines, Stiffness and Strength of Materials, Transmission and Conversion of Energy by Fluids.

Senior elective, three hours per week. Credit three hours.

Text: Cotterill, *Applied Mechanics*, supplemented by lectures and notes.

33b. APPLIED MECHANICS. *Lectures.* (Dean)

Continuation of 33a. Credit three hours.

35a. MATHEMATICAL THEORY OF ELECTRICITY AND MAGNETISM. *Lectures.* (Dean)

This course is intended only for students with special mathematical aptitude. Credit three hours.

Texts: Pidduck, *A Treatise on Electricity.*
Berg, *Electrical Engineering.*
Lyons, *Problems in Electrical Engineering.*
Pender, *Principles of Electrical Engineering.*

35b. MATHEMATICAL THEORY OF ELECTRICITY AND MAGNETISM. (Dean)

Continuation of 35a.

Whether the subject is treated from the standpoint of pure physics or that of electrical engineering depends on the choice of the students electing the course.

MECHANICS

Associate Professor Garrett.

15a. STATICS. *Lectures.* (Garrett)

It is the aim of this course to train the student to apply the principles of statics to practical rather than theoretical problems.

Prerequisites: Mathematics 11a and 11b.

Required in I., II., III., V., VI. and VII.

Junior year, four hours' lectures per week, first half of either semester; credit two hours.

Text: Maurer, *Technical Mechanics.*
Notes by instructor.

17a. MECHANICS OF MATERIALS. *Lectures.* (Garrett)

The more elementary and fundamental parts of the subject are here taken up. The student is given a thorough drill in the application of principles to simple problems of design and in the use of standard handbooks.

Prerequisite: Mathematics 15a.

Required in I., II., III., V., VI. and VII.

Junior year, second half either semester, four hours per week. Credit two hours.

Text: Merriman, *Mechanics of Materials.*

19b. MECHANICS OF MATERIALS. *Lectures.* (Garrett)

This course begins with the study of the elastic curve and includes the more advanced topics. As in the preceding course, a thorough drill in the practical application of the principles developed forms an important part of the work.

Prerequisite: Mathematics 17a.

Required in I., II., III., V., VI. and VII.

Junior year, first half either semester, four hours per week. Credit two hours.

Text: Merriman, *Mechanics of Materials.*

21b. DYNAMICS. *Lectures.* (Garrett)

This course includes kinematics and kinetics with technical applications.

Prerequisite: Mathematics 15a.

Required in I., II., III., V., VI. and VII.

Junior year, second half of either semester, four hours per week. Credit two hours.

Text: Maurer, *Technical Mechanics.*

After the school year 1916-17, the work in Mechanics will be grouped under the following course numbers:

17b. MECHANICS. *Lectures.* (Garrett)

A course in Statics and Dynamics as outlined above under course numbers 15a and 21b.

Prerequisites: Mathematics 11a and 11b.

Required in I., II., III., V., VI. and VII.

Sophomore year, second semester, four hours per week. Credit four hours.

Text: Maurer, *Technical Mechanics.*

19a. MECHANICS OF MATERIALS. *Lectures.* (Garrett)

A course in Mechanics of Materials as outlined above under course numbers 17a and 19b.

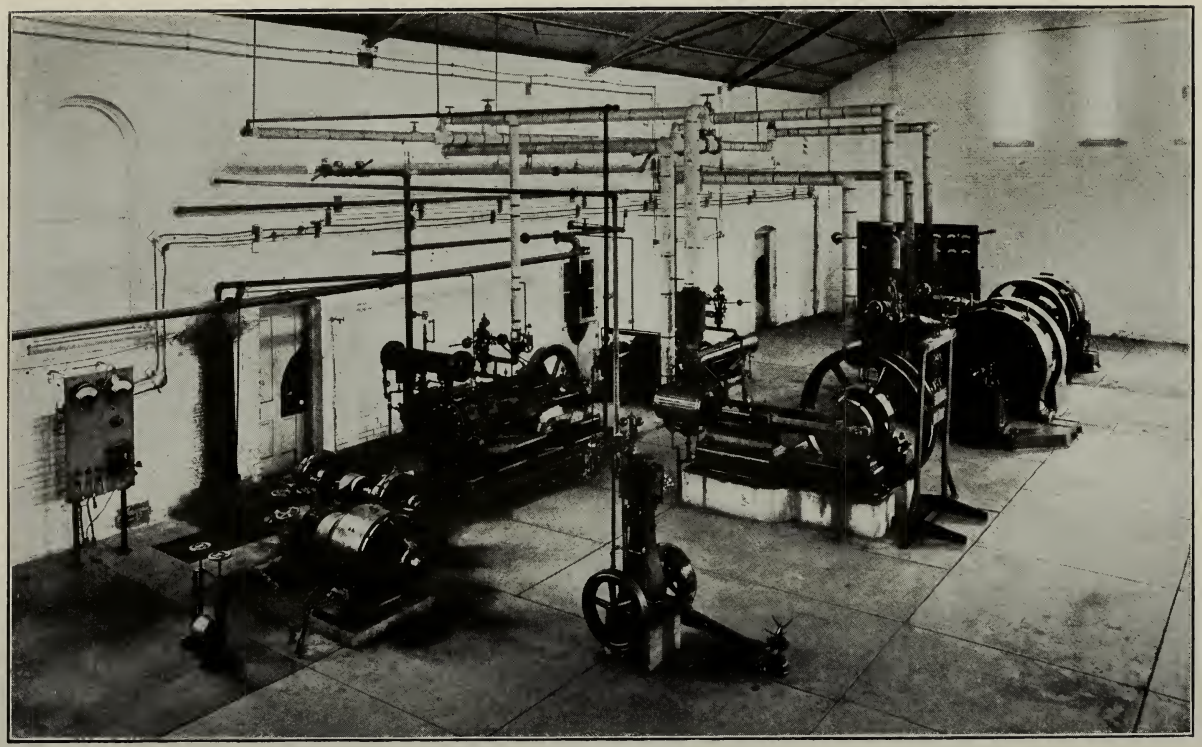
Prerequisite: Mechanics 17b.

Required in I., II., III., V., VI. and VII.

Junior year, first semester, four hours per week. Credit four hours.

Text: Merriman, *Mechanics of Materials.*

MECHANICAL HALL



STEAM LABORATORY.

MECHANICAL ENGINEERING

PROFESSOR DICKERSON, ASSISTANT PROFESSOR BOWEN, MR. DUFFY, MR. COLE, MR. ASHLOCK, MR. BARDSLEY, MR. SHIPLEY, MR. ZOLLER.

The course for Juniors and Seniors in Mechanical Engineering are conducted in the lecture and drafting rooms in Norwood Hall, the experimental laboratories are located in the Power Plant Building and the drawing and shop practice are given in Mechanical Hall.

Equipment.

The power plant is used for experimental purposes, and comprises a strictly modern and thoroughly equipped laboratory. The machinery available for testing purposes includes four 130-h. p. Heine safety boilers, especially equipped with openings in the setting for temperature and draft measurements in furnace, combustion chamber and flues; a 13 by 14 Erie Ball engine direct connected to a 75 kw. 220 volt D. C. Westinghouse generator; a 10 by 12 Ideal engine direct connected to a 50 kw. 220 volt D. C. Westinghouse generator; a 12 by 11 General Electric marine type engine direct connected to a 50 k. v. a. 220 volts, 60 cycle, three-phase generator with direct connected exciter; a 10 kw. 220 volt Curtis steam turbo generator; a 9 by 14 Brownell engine equipped with a rope friction brake; a 5 by 7 Davis and Rankin vertical engine equipped with a Prony brake; a 21-h. p. Otto four strokes per cycle gas engine belted to a General Electric 15 kw. 220 volt D. C. interpole generator, and to a two-stage Worthington centrifugal pump; a 3-h. p. Ferro two strokes per cycle portable gas engine; a D. C. switchboard with a panel for each generator and two for distribution switches, equipped with a Tirrill voltage regulator, a Thompson recording watt-hour meter, circuit breakers for each generator, and the usual ammeters and voltmeter; an A. C. switchboard with voltmeter, ammeters, wattmeter, and watt-hour meter. The pneumatic equipment includes a Laidlow-Dunn-Gordon air compressor, a Rand Imperial air compressor, a Sullivan straight-line two-stage air compressor, a 72-inch ventilating fan, a 36-inch ventilating fan, a 60-inch Buffalo forge blower, an experimental fan capable of delivering 250 cu. ft. of air per second at six inches of water pressure, two cylindrical steel tanks 6 ft. by 15 ft. for measuring air by water displacement.

The Ball and Ideal engines are equipped with a 20 in. shell Griscom-Russell surface condenser with a Blake vacuum pump.

The laboratory also contains a complete Wickes vertical boiler and engine ten horsepower plant fitted for testing purposes.

There is a complete steam and pumping plant at the experimental mine, where laboratory practice is also obtained.

The instrument room of the Mechanical Laboratory contains a good line of instruments used for testing purposes, some of which are listed below.

Parr and Roland-Wild coal calorimeters; Ellison throttling and evaporating moisture calorimeter; Peabody, and Schaeffer and Budenberg moisture calorimeters; General Electric Co., and Gebhart portable steam flow meters; Hays, and Orsat flue gas apparatus; Crosby, Thompson, Robertson, Schaeffer and Budenberg, and American steam and gas engine indicators; Schaeffer and Budenberg continuous drum indicator; Amsler, Crosby, Willis, and Keuffel and Esser planimeters; various indicating and recording steam gages; Crosby steam gage testers; Tycos portable pyrometer; cold and hot water meters; thermometers, manometers, tachometers and speed counters; and Prony friction brakes.

The shops are thoroughly equipped with machinery and benches adapted to instruction. The wood bench-work room contains twenty double benches with separate sets of hand tools. The lathe room is equipped with twenty Fay & Egan 12-in. swing college wood lathes and iron shears. The other machines in the lathe room include a Fay & Egan 27-in. planer, a Fay & Egan band saw with 30-in. wheels, Fay & Egan joiner, an Oliver universal saw-table, two Oliver wood trimmers, a mortise machine, jig saw, grindstones, and other necessary tools.

For instruction in forge work there are twenty-four Buffalo Forge Company down-draft forges, power hammer, drill press, power shears, and grinder.

The metal-working room contains:

One 20-in. by 8-ft. Reed Lathe.
One 12-in. by 6-ft. Reed Lathe.
One 14-in. by 6-ft. Hendey Lathe.
One 14-in. by 6-ft. American Lathe.
One No. 2A Brown & Sharpe Universal Milling Machine.
One No. 2 Universal Norton Grinder.
One Hendey 15-in. Pillar Shaper.
One Dwight Sensitive Drill.
One Barnes 22-in. Swing Upright Drill Press.
One 24-in. Morse Double Emery Grinder.
One 24-in. by 24-in. by 6-ft. Chandler Planer.
Two Greenard Arbor Presses, No. 3½ and No. 1.
One No. 1 Burr Cold Saw.
One 3-fire Chicago Flexible Shaft Gas Furnace.

All of the above-mentioned iron-working machinery is of latest design and driven by individual motors. The benches in the lathe room have hardwood tops mounted on standard Brown & Sharpe bench legs. Twenty-four machinist vises, twelve of which have the swivel base and jaw, equip the shop for bench work.

The drawing rooms are equipped with individual drawing tables and will accommodate two hundred and forty students working in two sections.

Courses.

1b. DESCRIPTIVE GEOMETRY. *Lectures and Problems.*

(Duffy, Ashlock, Shipley)

The usual textbook work is reinforced with blackboard exercises in presenting the projections of familiar objects, intersections of plane and curved surfaces, sections, developments, and shades and shadows. The afternoons in the drawing room are spent in solving in neat form more elaborate exercises.

Prerequisites: Entrance requirements.

Required in I., II., III., IV., V., VI. and VII.

Freshman year, second semester, four hours per week. Credit two and one-half hours.

Text: Blessing and Darling, *Descriptive Geometry.*

2a. MECHANICAL DRAWING. *Laboratory.*

(Duffy, Bardsley, Zoller)

The student is given practice in geometrical construction until familiar with the nature, care and use of drafting instruments and then after a careful study of the principles of orthographic projections, intersection and development, is thoroughly drilled in free-hand lettering. The course is completed by making sketches, detail and assembled working drawings which may be used for pattern making in the shop.

Prerequisites: Entrance requirements.

Required in I., II., III., IV., V., VI. and VII.

Freshman year, first semester, six hours per week. Credit three hours.

Text: French, *Engineering Drawing.*

2b. MECHANICAL DRAWING. *Laboratory.*

(Duffy, Ashlock, Bardsley)

A continuation of Mechanical Engineering 2a.

Prerequisite: Mechanical Engineering 2a.

Required in I., II., III., IV., V., VI. and VII.

Freshman year, second semester, three hours per week. Credit one and one-half hours.

3a. MECHANISM. *Lectures.* (Dickerson)

In this course are studied the principles which underly the action of the elementary combinations of which all machines are composed, also the motions and velocities of linkages, cams, and gears.

Prerequisites: Mechanical Engineering 4a and 18b.

Required in V. and VI.

Junior year, first semester, three hours per week. Credit three hours.

Text: Keown, *Mechanism.*

4a. MACHINE DRAWING. *Laboratory.* (Duffy)

This course follows the work given in Mechanical Drawing in the Freshman year. It includes drawing exercises in gearing, power, transmission, and the simpler machines used in mining, ore dressing, and metallurgy. In this way, the principles of elementary machine design are taught.

Prerequisites: Mechanical Engineering 1b, 2a and 2b.

Required in V. and VI.

Sophomore year, first semester, four hours per week. Credit two hours.

Text: Low, *Machine Design.*

5a and 5b. BOILERS AND ENGINES. *Lectures.*

(Dickerson)

This course takes up the consideration of the construction and operation of the various well known types of boilers and engines and their accessories. Under the boiler part is included chimneys and boiler settings; under the engine part is included the simple and multi-expansion Corliss engines, uniflow engines, steam turbines, and gas engines.

Prerequisites: Physics 1a, 2a, 3b and 4b.

Required in I., III., V., VI. and VII.

Junior year, first semester, three hours per week. Credit three hours.

Text: Spanker, Greene and Marshall, *Elements of Steam Engineering.*

6b. STEAM LABORATORY, *Laboratory.* (Dickerson)

A laboratory course given to familiarize the student with the instruments used in engineering investigations, also to give train-

ing in securing data, reporting, and analyzing results obtained from experiments conducted on boilers and steam and gas engines.

Prerequisites: To accompany or to be preceded by Mechanical Engineering 5a or 5b.

Required in III., VI. and VII.

Junior year, second semester, three hours per week. Credit one and one-half hour.

7b. VALVE GEARS. *Lectures and Problems.* (Dickerson)

The study of Valve Gears is essentially a study of the relative motions and simultaneous positions of the piston, crank and valve of an engine. This course deals principally with the valve and valve diagrams, shaft governors, Corliss and poppet valve gears and the reversing gears as applied to steam engines.

Prerequisites: Mechanical Engineering 3a and 5a or 5b.

Required in V.

Junior year, second semester, two hours per week. Credit two hours.

Text: Fessenden, *Valve Gears.*

8b. MECHANICAL LABORATORY. *Laboratory.*

(Dickerson)

A course similar to Mechanical Engineering 6b. This course also includes experiments on air compressors.

Prerequisite: To accompany or to be preceded by Mechanical Engineering 5a or 5b.

Required I. and VI.

Junior year, second semester, three hours per week. Credit one and one-half hour.

9a. POWER PLANTS. *Lectures and Laboratory.*

(Dickerson)

This course attempts to cover the broad scope of classifying the various types of machines used in power plants according to their adaptability to service, space, economy, and cost; also to give the student some idea of the commercial side of engineering. A laboratory period gives opportunity for studying the general lay-outs and operation of power plants and also experimental data which is obtained from complete plant tests.

Prerequisites: Mechanical Engineering 5a or 5b and 6b or 8b.

Required in V. and VI.

Senior year, first semester, six hours per week. Credit four and one-half.

Text: Fernald & Orrok, *Engineering of Power Plants.*

9b. THERMODYNAMICS. *Lectures.* (Dickerson)

A course in theoretical thermodynamics, covering the laws and fundamental equations of gases and their application to the steam engine. Also a discussion of the principles governing the action of air compressors, gas engines, refrigerating machines and steam turbines.

Prerequisites: Mechanical Engineering 5a or 5b and 6b or 8b.

Required in V. and VI.

Junior year, second semester, three hours per week. Credit three hours.

Text: Moyer and Calderwood, *Engineering Thermodynamics.*

11a. COMPRESSED AIR. *Lectures.* (Harris)

This course covers the theory of air compression, both in reciprocating machines and in centrifugal machines; also the measurement and transmission of air, and its application to the industries.

The problems include laboratory work in testing compressors and fans, determination of friction in pipes, flow through orifices, and the solution of problems, such as come up in practice.

Prerequisites: Mathematics 19a, Mechanical Engineering 5a or 5b and 6b or 8b.

Elective.

Senior year, first semester, three hours per week. Credit three hours.

Text: Harris, *Compressed Air.*

12a or b. WOOD WORK. *Laboratory.* (Bowen, Cole)

The work in the wood shop aims to train the student in the use of wood-working tools and machinery and to familiarize him with the properties of the common woods. All work is done from drawings.

Prerequisites: Entrance requirements.

Required in I., II., III., IV., V., VI. and VII.

Freshman year, first semester, three hours per week. Credit one and one-half hours.

14a or b. FORGE WORK. *Laboratory.* (Bowen, Cole)

This course begins with simple exercises in drawing, upsetting, bending, twisting, punching, and welding. The work gradually becomes more difficult, such as making eye-bolts, chains, and tongs. Tool-making is then begun by making screwdrivers,hammers, chisels, and a complete set of lathe tools to be used later in the machine shop. This work is fully illustrated by drawings and lectures on the subject, covering the properties of the different grades of iron and steel. The student is made familiar with the

best grade of steel to be used for any required purpose, and the correct shape and temper necessary for the best work in cutting iron, steel, brass and stone. The final part of this work is the testing of rock-drills on different grades of steel used.

Prerequisite: Entrance requirements.

Required in I., II., III., IV., V., VI. and VII.

Freshman year, second semester, three hours per week. Credit one and one-half hours.

15b. INTERNAL COMBUSTION ENGINES. *Lectures.* (Dickerson)

This course includes the theory of Internal Combustion Engines as well as the construction and operating features of the various types of automobile, stationary oil engines of small sizes, Diesel and other engines of large types. The gas producer is also studied.

Prerequisites: Mathematics 19a, Mechanical Engineering 5a or 5b and 6b or 8b.

Elective.

Senior year, second semester, three hours per week. Credit three hours.

Text: Streeter, *Internal Combustion Engines.*

16a. FOUNDRY. *Laboratory.* (Bowen, Cole)

This course comprises instruction and practice in the use of foundry tools and equipment and in tempering of sand, preparation of sands for core binding and core making. It also includes bench, floor, pit, sweep, and machine molding; charging of cupola and pouring of metals.

Prerequisites: Mechanical Engineering 12a and 14b.

Required in V. and VI.

Sophomore year, first semester, three hours per week. Credit one and one-half hours.

17b. HEATING AND VENTILATING. *Lectures and Problems.* (Dickerson)

A study of the principles of design for heating and ventilating private and public buildings. An example is used for illustrating the various systems of furnace heating, hot water and steam and comparisons made. The central heating system is also studied.

Prerequisites: Mechanical Engineering 9b.

Elective.

Senior year, second semester, three hours per week. Credit three hours.

Text: Hoffman, *Handbook for Heating and Ventilating Engineers.*

18b. MACHINE SHOP. *Laboratory.* (Bowen, Cole)

This course begins with chipping to a line, filing to a dimension, and scraping to a surface plate. Machine operation is then begun; the principles and uses of the drill-press, lathe, planer, shaper, and milling machines are taught by lectures followed by practical work at each machine. After a reasonable time, skill is attained in operating the various machines through a course of graded exercises. In this work use is made of the vernier, micrometer, thread-micrometer, and gear-tooth caliper. Entire machines are also built, such as lathes, gasoline engines, wood trimmers. The degree of accuracy thus acquired enables the student to use eye and hand in unison, and is a lasting benefit in teaching exactness in statement and measurement.

Prerequisite: Mechanical Engineering 14a or 14b.

First or second semester, six hours per week. Credit three hours.

19b. INDUSTRIAL ENGINEERING. *Lectures.*

(Dickerson)

This course comprises lectures on the construction and the arrangement of buildings for manufacturing plants; the heating and lighting of such buildings; the installation and arrangement of machinery in them and also the maintenance of plants is considered. Shop management is especially studied during the course.

Prerequisite: Mechanical Engineering 9a.

Required in V.

Senior year, second semester, three hours per week. Credit three hours.

20a. MACHINE DESIGN. *Laboratory.* (Dickerson, Duffy)

The individual shapes and strength of the working parts of machines are studied, keeping in mind the frame upon which these parts are to be assembled. Such problems as the design of bearings, clutches, hooks, pulleys and also machine tools as found in machine shops.

Prerequisites: Mechanical Engineering 3a, 4a, and 18b.

Required in V.

Junior year, first semester, six hours per week. Credit three hours.

Text: Halsey, *Handbook for Machine Designers.*

20b. ENGINE DESIGN. *Laboratory.* (Dickerson, Duffy)

In this course the student completely designs a steam or gas engine, making comparisons with "Manufacturers' Averages." The report includes the calculation and detailed drawings.

Prerequisite: Mechanical Engineering 20a.

Required in V.

Senior year, second semester six hours per week. Credit three hours.

Text: Halsey, *Handbook for Machine Designers.*

22a. MACHINE DESIGN. *Laboratory.* (Dickerson, Duffy)

This course takes up the design of the shapes and strength of the working parts of machines similar to that in 20a.

Prerequisites: Mechanical Engineering 3a, 4a, and 18b.

Required in VI.

Junior year, first semester, three hours per week. Credit one and one-half.

24a. POWER PLANT DESIGN. *Laboratory.*

(Dickerson, Duffy)

The student makes preliminary surveys, and from this, with what further data needed, designs a complete power plant. The generation and sale of the power as well as the by-products, such as steam for heating, are taken into account. Drawings for proposed plants are made and plans for reconstruction are worked up. Maintenance, stand by losses, insurance and depreciation are considered in the selection of the machinery.

Prerequisite: Mechanical Engineering 9a.

Required in V.

Senior year, first semester, six hours per week. Credit three hours.

METALLURGY AND ORE DRESSING

Associate Professor Mann, Assistant Professor Clayton, Mr. Doeling, Mr. Pugh, Mr. Horner.

Equipment.

The assay laboratory has a floor space of forty-eight hundred square feet. In the main room are twenty coal-fired, double-muffle assay furnaces, twelve gasoline-fired muffle furnaces, and ten coke-fired furnaces. Desks containing lockers, pulp balances, and fluxes are arranged close to the furnaces.

A room 16 by 16 feet, separated from the furnace laboratory by glass partitions, is used for parting. There are in this room the necessary hot plates, acid jars, and annealing muffles. The desks in this laboratory are topped with white tiling.

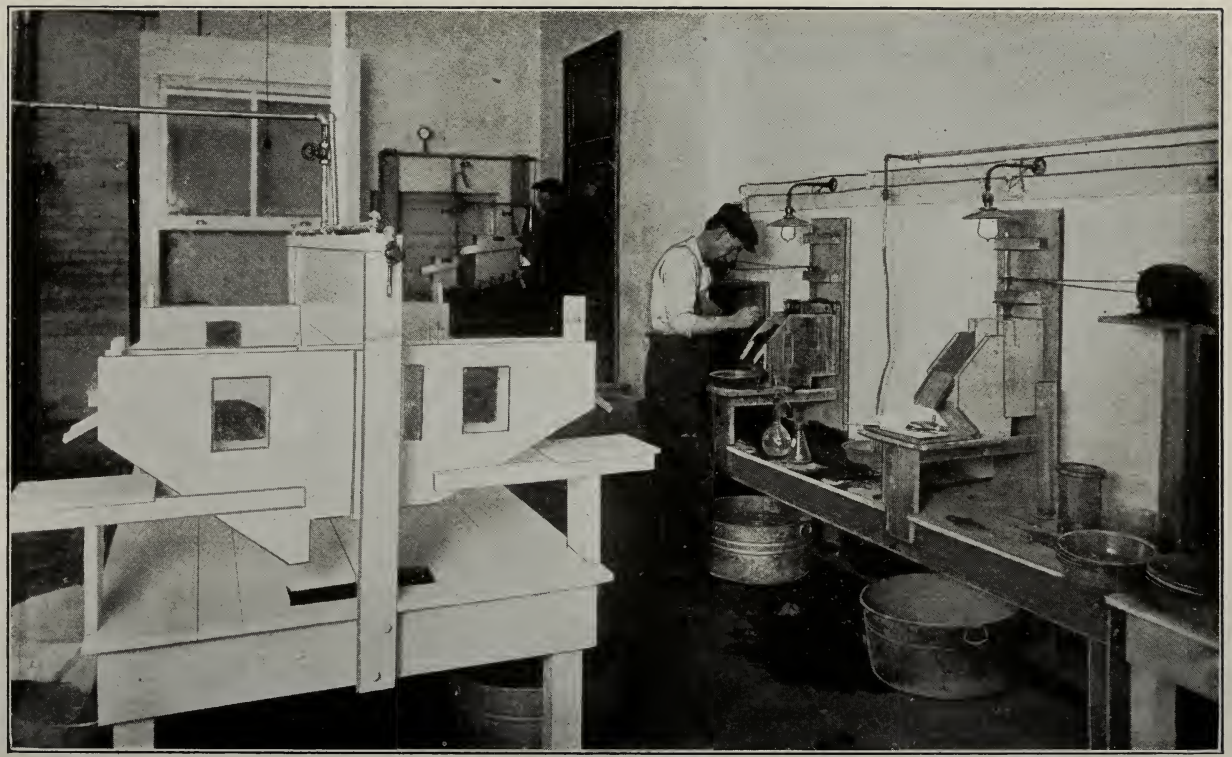
The balance room is 20 by 20 feet and is lighted only from the north. It is easily kept at constant temperature. There are twenty-four balances suitable for weighing gold. A number of these balances have the multiple-rider attachment.

For chemical work in connection with metallurgy there is a well-lighted room having fifty-six lockers and fifty-six desks. Each desk is provided with gas, compressed air, and water. There is in the room ample hood space; in fact, the laboratory has everything necessary for general chemical work.

There is, in main furnace room, a circular water-jacket blast furnace 20 inches in diameter at the tuyeres and 7-foot smelting column. This furnace is used for lead and copper smelting. For roasting ores a hand reverberatory furnace, with a hearth 4½ by 9 feet, is provided. This laboratory contains also an experimental pot roaster, an experimental zinc distilling furnace, direct reading and recording La Chatlier thermo-electric pyrometers, and a Wanner optical pyrometer.

A stock room, containing chemicals, clay goods, glassware, and other supplies, serves all the laboratories. The ore-sample room is especially well equipped. It contains more than 1,000 samples of ore of varied classes. Each sample is stored away in paper sacks, all ready for issuing to the students. Each sample has been prepared and carefully assayed. Enough of each lot of ore has been prepared to give 200 to 300 samples of the same lot. The sample room, therefore, contains more than 1,000 different samples of ore, each sample being divided into 200 or more smaller samples, each of the smaller samples being ready for immediate issue.

ASSAY LABORATORY.



FLOTATION LABORATORY.

Throughout the metallurgical and ore-dressing laboratories care has been taken that each furnace, each piece of apparatus, should be so arranged as to be fitted best for that testing work which must be so great a part of the student's work. In all the laboratory work, in addition to demonstrating the theories and principles explained in the classroom, the attempt is made to give the man ability to do a day's work and to teach him to use both his head and his hands.

The main floor of the new ore-dressing laboratory occupies a space of forty-eight hundred square feet and a mezzanine floor provides an additional space of thirteen hundred square feet. The equipment of the laboratory is as follows: The crushing and sampling department contains a gyratory breaker, a Dodge breaker, a pair of 9-in. by 12-in. rolls, two plane shaking screens, two Vezin samplers, two bucket elevators, three belt conveyors and six ore storage bins, each equipped with an automatic feeder, For fine crushing and amalgamation tests are provided a three-stamp mill, with amalgamated plates and a 3½ foot Huntington mill.

Ores are prepared for concentration by the following series of machines: Three trommel screens, a duplex Callow traveling belt screen, a Richards pulsator classifier, a four-spigot Richards vortex classifier, a three-spigot cone classifier, a small Tamarack classifier, and four Callow settling cones.

Methods of concentrating coarsely crushed ores are illustrated by three five-cell differential motion Harz jigs, a Richards pulsator jig, and a small model of the Hancock jig. Sands are treated on two laboratory-size Wilfley tables, one laboratory Card table, one Deister Overstrom table, and a laboratory James table. A four-foot Frue vanner and a five-foot Sperry slimer are provided for the treatment of fine materials.

Two direct-connected, motor-driven centrifugal sand pumps are used for elevating finely crushed ore to the screening and classification system.

The sample finishing room contains a small Blake crusher, a small gyratory breaker, a disc grinder, a coffee mill, a pair of rolls, a number of bucking boards and mullers, a laboratory tube mill, a RoTap testing Sieve shaker and an electric sample dryer.

The cyanide unit contains a laboratory leaching plant with all necessary tanks, a 16-in. Hendryx clay agitator, a 14-in. Hendryx combination agitator and filter, and a six-leaf 12-in. by 12-in. filter press.

Ores suited to a magnetic concentration are treated on a Knowles magnetic separator, and for the preparation of such ores a cylindrical dryer and roaster, together with a plane impact screen for dry sizing, is provided.

For testing ores by flotation, the laboratory is equipped with machines that represent the latest thing in the way of oil flotation. There are eight machines of the mineral separation type, four of which are of the modified air lift type, one Janney machine (the gift of D. C. Jackling), and one Callow machine. Each machine is arranged so that it can be run independent of all others or in combination.

The laboratory, which is lighted by two "daylight" nitrogen lamps, is well equipped with hot plates, drying areas, water and air pipes, and other equipment that goes toward facilitating work.

We have on hand about one hundred and fifty oils, most of which have been carefully classified according to their merits as flotation oils. Besides the oils, we have a large number of reagents that are used as addition agents in the flotation process.

Throughout the mill, wherever possible, the practice of driving each machine with an individual motor has been followed.

It is recognized that the school cannot give students, in the brief time at its disposal, that skill which comes from long practice, but it is the aim to give such training in the fundamental principles and their application that students may become useful immediately on their entrance into the actual practice of their chosen profession. All metallurgical courses are accompanied by graded metallurgical problems.

An important feature of the instruction is experimental investigation in the metallurgical treatment of various ores.

1a. FIRE ASSAYING. *Lectures.* (Clayton)

This course deals with the theory of fire assaying as practiced in the laboratory. The points discussed are outlined under Metallurgy 2b.

Prerequisites: Chemistry 1a and 2a.

Required in I.

Junior year, first semester, two hours per week. Credit two hours.

Texts: Lodge, *Notes on Assaying.*
Fulton, *Assaying.*
Smith, *Sampling and Assaying of the Precious Metals.*

1b. FIRE ASSAYING. *Lectures.* (Clayton)

This course deals with the theory of Fire Assaying as practiced in the laboratory. The points discussed are outlined under Metallurgy 2b.

Prerequisites: Chemistry 1a and 2a.

Required in II. and VII.

Junior year, second semester, two hours per week. Credit two hours.

Texts: Lodge, *Notes on Assaying.*
Fulton, *Assaying.*
Smith, *Sampling and Assaying of the Precious Metals.*

2b. FIRE ASSAYING. *Laboratory.*

(Mann, Clayton, Doeling, Pugh, Horner)

This work includes the assay, by scorification and crucible methods of ores from the various districts of the United States. Copper ores, copper mattes, and copper bullions are assayed by fire and by the combination method. Lead ores and furnace products are assayed for lead and for gold and silver. Assays of cyanide solutions, of zinc-box residues, of silver bullion, of gold bullion, of lead bullion and of silver-mill precipitate, are included in this course. During the course the student has practice with coal furnaces, coke furnaces, and gasoline furnaces. Besides doing the ordinary work of assaying, the student studies the losses occurring. He learns the effects of different schemes of firing the furnaces by making analysis of the flue gases and by pyrometric measurements. The laboratory is so arranged that even with large classes a student is not hampered by other students and he learns to handle a large amount of work with the best utilization of his time.

Prerequisites: Chemistry 1a and 2a. To be preceded by Geology and Mineralogy 1a.

Required in II.

Junior year, second semester, nine hours per week. Credit four and one-half hours.

Texts: Lodge, *Notes on Assaying.*
Fulton, *Assaying.*

2a. FIRE ASSAYING. *Laboratory.*

This course covers the work outlined in Metallurgy 2b briefly.

Prerequisites: Chemistry 1a and 2a. To be preceded or accompanied by Geology and Mineralogy 1a.

Required in I.

Junior year, first semester, six hours per week. Credit three hours.

4b. FIRE ASSAYING. *Laboratory.*

This course attempts to briefly cover some of the more important operations as outlined in Metallurgy 2b.

Prerequisites: Chemistry 1a and 2a.

Required in VII.

Junior year, second semester, three hours per week. Credit one and one-half hours.

3b. METALLURGY AND THE METALLURGY OF IRON AND STEEL. *Lectures.* (Clayton)

This course covers the same as outlined under Metallurgy No. 39a and 39b, but with less detail. It is intended primarily for the men studying Mining and Civil Engineering.

Prerequisites: Chemistry, Geology and Mineralogy.

Required in I. and III.

Junior year, second semester, four hours a week. Credit four hours.

Texts: Stoughton, *Metallurgy of Iron and Steel.*
Fulton, *Principles of Metallurgy.*
Hofman, *General Metallurgy.*
Richards, *Metallurgical Calculations, Vols. I. and III.*

Discontinued after 1916-17.

5a. METALLURGY OF THE NON-FERROUS METALS. *Lectures.* (Mann)

This course includes a study of the metallurgy of lead, copper, zinc, gold, silver, tin, antimony, and aluminum. The greater part of the time is spent on the metallurgy of lead, copper, zinc, gold, and silver.

Metallurgy of Lead. The course in the metallurgy of lead includes work along the following general lines: The properties and uses of lead, its alloys, and compounds. The ores of lead and methods and principles of their sale. Principles and practice of sampling ores and products. The general principles made use of in the winning of lead from its ores. The treatment of lead ores in the reverberatory smelting furnace. The winning of lead from its ores by smelting in the ore hearth or Scotch hearth, considerable attention being paid to this method on account of its importance with the ores of the Mississippi Valley. The roasting of lead ores and the strides that have recently been made in this important preliminary in the lead blast-furnace. The winning of ores in the lead blast-furnace. This heading is, of course, an important one in the subject, and under it are taken up the blast-furnace plant, the chemistry of the blast-furnace, the calculation of furnace charges, the calculation of costs of smelting, the handling of products, particularly the smoke or fume. The desilveration of base bullion by means of the Parkes, Pattison, and cupellation processes, as well as by the Betts process. Throughout this course, as well as the other courses in this department, the work is accompanied by problems which bring out the ideas that the class-room work considers.

Texts: Hofman, *Metallurgy of Lead.*
Collins, *Metallurgy of Lead.*
The Articles Appearing in the Technical Journals.

METALLURGY OF COPPER. The metallurgy of copper is considered along the following general lines: The properties and uses of copper, its compounds, and its alloys. The markets for copper and its ores and the principles underlying their sale and price. The ores of copper. The smelting of roasted and oxidized ores of copper to black copper is touched only briefly. The roasting of copper ores as a preliminary to blast-furnace and reverberatory smelting. The handling of the smoke from copper furnaces to save the values contained therein and to remove from these gases their injurious constituents. The smelting of roasted ores to matte in the reverberatory furnace. The smelting of roasted ore to matte in the blast-furnace either with or without the attempt to volatilize a considerable portion of the sulphur. The smelting of raw massive sulphides to matte in the balst-furnace, or pyrite smelting. The converting of copper matte to blister copper in the basic and in the acid converter. The furnace refining of copper. The production of copper from matte by the various roast-reaction of roast smelting methods. The electrolytic refining of copper.

Texts: Peters, *Practice of Copper Smelting.*
Peters, *Principles of Copper Smelting.*
Hofman, *Metallurgy of Copper.*
References in the Technical Journals.

METALLURGY OF ZINC. The metallurgy of zinc is considered under the following headings: The properties and uses of zinc, its alloys, and its compounds. The ores of zinc and the methods and principles underlying their sale. The roasting of zinc ores, with a brief study of the use of zinc ores as a source of sulphuric acid. The distillation of zinc ores and the furnaces suited for this purpose. The factors on which the success of the distillation depends. The manufacture of retorts and condensers. The laws of condensation of vapor to liquid and their application to the condensation of zinc vapors. The products of zinc smelting, and the methods of handling and treating these products. The cost of smelting zinc ores figured on the basis of a number of typical ores. The refining of spelter. The markets for spelter and the various brands of spelter. Special schemes other than the ordinary methods that have been used or proposed for use in the winning of zinc from its ores. The manufacture of zinc oxide pigment. Throughout the course problems are given to illustrate the ideas set forth in the class.

Text: Ingalls, *Zinc.*

METALLURGY OF GOLD AND SILVER. The metallurgy of gold. The work of this course includes lectures and recitations along the following general lines: The properties of gold, gold alloys, and

the compounds of golds. The winning of gold from placer ground by dredging and hydraulizing, including methods of investigating the value of placers. The chlorination and bromination of gold ores are considered more in the light of the historic value of these processes than for their present importance as schemes of gold extraction. The amalgamation methods for silver and gold ores are taken up in detail in the course in ore dressing.

The metallurgy of silver is considered as suggested by the following headings: The properties of silver, of its alloys, and of the compounds of silver. The winning of silver from its ores by the various leaching schemes that were formerly of greater importance than at present. These schemes include the Augustin process, the Ziervogel or Argo process, the various methods of hyposulphite leaching; they are considered only briefly. The greater part of the time of the course in gold and silver is devoted to the study of the cyanide process, which is considered in considerable detail. The parting of gold and silver by the various acid and electrolytic schemes. The winning of gold and silver from their ores by the various smelting schemes is considered under the head of the metallurgy of lead and copper.

Texts: Rose, *Metallurgy of Gold.*
Collins, *Metallurgy of Silver.*
Julian and Smart, *Cyaniding.*
Clennell, *Cyaniding.*
The Technical Journals.

Prerequisites: Metallurgy 39b and Chemistry 6b.

Senior year, first semester, four hours per week. Credit four hours.

Required in II.

5b. METALLURGY OF THE NON-FERROUS METALS. *Lectures.* (Mann)

This is a continuation of Metallurgy 5a.

Prerequisites: Metallurgy 39b and Chemistry 6b.

Senior year, second semester, three hours per week. Credit three hours.

6a. METALLURGY. *Laboratory.* (Mann, Clayton)

This course covers the testing of ores for process treatment. Ores are tested by cyaniding, chlorination, amalgamation, lixiviation, concentration, and by combination methods. With aid of smelter schedules, the smelting costs are calculated and the net dollars and cents returns are balanced against the best results by any method, or combination of methods, worked out in the laboratory. The endeavor is made, not only to teach metallurgical

principles in the laboratory, but also to bring home to the student the great effect that freight rates and such other factors have on the treatment which an ore should receive. Experiments are made in the reverberatory and the "pot" roasting of ores, and on blast-furnace smelting of ores. Furnace heat equations are made by each student from data collected by himself.

Prerequisites: Metallurgy 1b, 2b and 3b.

Senior year, first semester, four hours per week. Credit 2.5 hours.

Text: Howe, *Metallurgy Laboratory Experiments.*

8a. METALLURGY. *Laboratory.* (Mann)

A more extended course than 6a. Planned for students specializing in metallurgy.

Prerequisites: As in 6a.

Senior year, first semester, seven hours per week. Credit four hours.

Recommended for II.

Text: As in 6a.

9a. ELECTRO-METALLURGY. *Lectures.* (Clayton)

Lectures are given covering the electro-metallurgical processes that are in use. Efficiency and engineering calculations based on these processes are given.

Prerequisites: Metallurgy 3b, Physics 1b and 3a, Chemistry 9a, 10a and 7a.

Senior year, first semester, four hours per week. Credit four hours.

10a. ELECTRO-METALLURGY. *Laboratory.* (Clayton)

This course gives a study of the principles of electro-metallurgy from the standpoint of experiments actually performed. Tests are made on the electrolytic refining of copper and of lead bullion. Experiments are performed and calculations as to efficiency are made on electric smelting.

Prerequisites: Physics 1b and 3a, Chemistry 9a, 10a and 7a Accompanied by Metallurgy 9a.

Senior year, first semester, six hours per week. Credit three hours.

10b. ADVANCED ELECTRO-METALLURGY. *Laboratory.* (Clayton)

This course is a continuation of Metallurgy 10a.

Prerequisites: Physics 1b and 3a, Chemistry 9a, 10a and 7a. Metallurgy 10a.

Senior year, second semester, three hours per week. Credit one and one-half hours.

12. SENIOR TRIP.

During the second semester of the Senior year a three weeks' trip is taken to Joplin, St. Louis, Flat River, and other points in the Southeast Missouri Lead District, for the purpose of studying the Mining, Ore Dressing, Smelting, Geology, and Power Plants of these districts. The metallurgy part of this trip is required of all candidates for degrees in Mining Engineering and Metallurgy who take Courses 5b Metallurgy and 33b Metallurgy.

Prerequisites: Metallurgy 5b, 33b.

Senior year, second semester.

13a. METALLURGY PROBLEMS. (Clayton)

These problems aim to cover the common ones that the metallurgist meets in practice.

Prerequisite: Metallurgy 3b. To accompany Metallurgy 5a.

Senior year, first semester, three hours per week. Credit three hours.

Text: Richards, *Metallurgical Calculations.*

15b. METALLURGICAL MEMOIRS. *Lectures.* (Mann)

The student in the Metallurgy Curriculum is required to do considerable amount of technical reading in German and English. Carefully prepared abstracts of valuable current articles are presented and read by each student.

Prerequisite: Metallurgy 5a.

Senior year, second semester, one hour per week. Credit one hour.

17a. METALLURGY CONFERENCE. *Lectures.* (Mann)

The lectures cover the work being given at the time in the laboratory in Metallurgy 6a.

Prerequisite: Metallurgy 3b. To accompany Metallurgy 6a.

Senior year, first semester, one hour per week. Credit one hour.

After 1916-17 this course is discontinued.

19a. METALLURGY PLANT. *Lectures.* (Mann)

The arrangement of various metallurgical works are studied. The advantages and disadvantages of different equipments are given.

Prerequisites: Metallurgy 3b, 5a, and 5b.

Graduate course, first semester, two hours per week. Credit two hours.

20a. METALLURGY PLANT DESIGN. *Laboratory.* (Mann)

This is a drafting-room course and the student is given problems to solve in detail, covering a part of the classroom discussions. Each student is required to submit complete drawings, specifications and estimates of cost.

Prerequisites, Shop Practice and Drawing 2b, Metallurgy 3b, 5a, and 5b.

Graduate course, first semester, six hours per week. Credit three hours.

21b. CYANIDING. *Lectures.* (Mann)

This course teaches the principles and practice of cyaniding. The student keeps up with the progress in the art. Attention is given in all the work to the cost of operation and to the schemes used and proposed for lessening the cost. A detailed study is made of the types of filter presses, crushing machinery, and other devices used in cyanide mills. Cyaniding is compared with other possible methods of treatment.

Prerequisites: Metallurgy 1b, 2b, and 3b.

Graduate course, second semester, three hours per week. Credit three hours.

22. CYANIDE LABORATORY. (Mann, Clayton)

The student in this course has an opportunity to test in the Laboratory the methods discussed in the classroom. The work is not routine, but the experiments are arranged to bring out a point under discussion, or to solve, if possible, the problems occurring at the time in the classroom.

Prerequisites: Metallurgy 1b, 2b, and 3b. To accompany Metallurgy 21a.

Graduate course, second semester, six hours per week. Credit three hours.

23b. ORE SUPPLY. *Lectures.* (Mann)

This course is intended to bring out the important subject of ore, flux, and fuel supplies. The subject is studied from a combined commercial and technical standpoint. The problems of valuing fluxes and fuels, of mixing ore so that the mixture shall command the lowest treatment rate, and of preparing, from the reduction works' standpoint, treatment charges for different classes of ores, are studied.

Prerequisites: Metallurgy 5a and 5b.

Graduate course, second semester, two hours per week. Credit two hours.

25a. METALLURGICAL RESEARCH. *Laboratory, Reading and Conferences.* (Mann)

Each graduate student elects a subject for special study. It is recommended that the work be along a different line from the subject chosen for thesis. The course consists principally of assigned reading, together with conferences with the professor on matter read. The laboratories are always open for the solving of any problem that may arise.

Prerequisites: Metallurgy 5a and 5b.

Graduate course, first semester, five hours per week. Credit five hours.

After 1916-17 this course will be given three times per week.

25b. METALLURGICAL RESEARCH. *Laboratory, Reading and Conferences.* (Mann)

This course is a continuation of Metallurgy 25a.

Prerequisite: Metallurgy 25a.

Graduate course, second semester, five hours per week. Credit five hours.

27b. ADVANCED METALLURGICAL PROBLEMS. *Lectures.* (Clayton)

This course has reference to the designing and proportioning of various types of furnaces for special duties and conditions.

Prerequisite: 13a.

Second semester, one hour per week.

Credit one hour.

29a. ALLOYS AND METALLOGRAPHY. *Lectures.* (Clayton)

These lectures deal with the theoretical and practical consideration that influence the structure and properties of alloys of different types.

Prerequisites: Chemistry 7a, Metallurgy 3b.

Senior year, first semester, two hours per week. Credit two hours.

After 1916-17 this course will be given second semester, three hours per week.

30a. ALLOYS AND METALLOGRAPHY. *Laboratory.* (Clayton)

This laboratory course is given in connection with the lectures, and deals chiefly with the micro-structure of iron and steel.

Prerequisites: Chemistry 7a, Metallurgy 3b.

Senior year, first semester, three hours per week. Credit 1.5 hours.

After 1916-17 this course will be given in the second semester.

32b. ALLOYS AND METALLOGRAPHY. *Laboratory.* (Clayton)

This course is intended for those who wish to devote more time to the study of the structure of Alloys than is possible with 30b.

Prerequisites: Chemistry 7a, Metallurgy 39b and 41b.

Senior year, second semester, six hours per week. Credit three hours.

33a. ORE DRESSING. *Lectures.* (Mann)

In this course the principles of mechanical ore treatment are discussed in detail. The construction and theory of machines are presented in lectures, supplemented by a full equipment of models, which show the design of all common ore-dressing appliances. The latter part of the course deals with the management of mills and with the adaptation of processes to the successful treatment of various ores.

Prerequisite: Metallurgy 31b.

Senior year, first semester, five hours per week. Credit five hours.

After 1916-17 three hours per week.

Text: Richards, *Textbook of Ore Dressing.*

33b. ORE DRESSING. *Lectures.* (Mann)

This course is a continuation of Metallurgy 33a.

Prerequisite: Metallurgy 33a.

Senior year, second semester, three hours per week. Credit three hours.

Text: Richards, *Textbook of Ore Dressing.*

34a. ORE DRESSING PROBLEMS. *Laboratory.* (Mann)

In this course advanced work is given in connection with the design of plants and machinery for the treatment of ores. The course includes the determination of a practical process for treating a given ore, and the design for a mill for utilizing this process.

Prerequisites: Metallurgy 1b, 2b, and 31b, Shop Practice and Drawing 2b. To be accompanied by Metallurgy 33a.

Senior year, first semester, three hours per week. Credit 1.5 hours.

After 1916-17 this course will be given six hours per week, second semester.

36b. ORE DRESSING LABORATORY. (Mann, Clayton)

The student becomes familiar with the operation and care of milling machinery by actual laboratory experience. All types and classes of machines are available to illustrate principles and practice as presented in the lecture work. The laboratory is so arranged that a number of mill schemes may be utilized and processes for treating a particular ore can be determined from mill tests on large quantities of the ore.

Prerequisites: Metallurgy 1b, 2b, and 33a. To be accompanied by Metallurgy 33b.

Senior year, second semester, six hours per week. Credit three hours.

38. JUNIOR TRIP.

At the end of the school year the members of the Junior Class take a three weeks' trip to Colorado and Utah, or other mining districts. The purpose of the trip is to give an opportunity for the study of the geology, mining, and concentration of ores in the districts visited.

Credit may also be obtained for this trip in the following manner:

The student may obtain employment at any mine, mill, or smelter of his own selection, for a period of not less than six weeks. This work will be accepted as a substitute for the regular trip only when accompanied by a suitable report on the mining, metallurgy, and geology of the district in which he is employed. Outlines of these reports will be furnished by the various departments. Affidavits will be furnished the students, to be signed by the mine or mill officials by whom he was employed, stating the time of such employment and nature of work.

Credit will be given for this course only to candidates for degrees of B. S. in Mining or Metallurgy.

Prerequisites: Mining 5b, Geology 3b, and Metallurgy 31b.

Junior year, Summer session. Credit six hours toward Senior electives in I. and II. Credit for mining part of trip two hours.

39b. GENERAL METALLURGY. *Lectures.* (Clayton)

This course is an introduction for the advanced metallurgical courses. The work is covered in a general way by the following headings: The properties of metals; the chemical equation from the standpoint of the metallurgist; methods of combustion; the temperature of combustion in any system and the effect thereon of certain variables; measurement of high temperatures; means of supplying oxygen for combustion, including stack design; metallurgical fuels and methods of firing, including a study of

coals, coke, charcoal, gases from producers, and liquid fuels; calorimetry; refractories and their uses; types of furnaces and the reasoning involved in their design; a general study of typical metallurgical operations, including pyrometallurgical, hydrometallurgical and electrometallurgical processes; slags in general; conduction, radiation, and convection from the standpoint of the metallurgist. In this course much attention is given to the methods of attaching various metallurgical problems.

Prerequisites: Chemistry 3b and 4b, Geology and Mineralogy 1b.

Required in I., II. and VII.

Junior year, second semester, three hours a week. Credit three hours.

Texts: Fulton, *Principles of Metallurgy.*
Hofman, *General Metallurgy.*
Richards, *Metallurgical Calculations.*
Burgess and Le Chatelier, *The Measurement of High Temperature.*

40b. JUNIOR METALLURGY LABORATORY.
(Clayton)

This course is intended for men following the metallurgy curriculum. It will take up in detail Pyrometry, Refractories, Fuel Testing, Gas Analysis, the Physical Properties of Metals, Cooling Curves, Roasting, Study of Slags, Use of the Microscope in Metallurgy and Ore Dressing, and Heat Conduction.

Prerequisites: To be accompanied by Metallurgy 39b.

Required in II.

Junior year, second semester, three hours per week. Credit one and one-half hours.

41b. METALLURGY OF IRON AND STEEL. *Lectures.*
(Clayton)

This course is intended for those intending to follow metallurgy. It takes up in detail the study of iron and steel and the work follows these general headings: The properties of iron and its alloys and compounds; specifications for standard irons and steels; the ores of iron and the principles underlying their valuation; the preparation of iron ores for the blast-furnace; the iron blast-furnace, its construction and operation; the manufacture of pig iron; the properties of pig iron, and the factors upon which these properties depend; the calculation of furnace charges; the chemistry of the blast-furnace; the metallurgical operation of the blast-furnace; blowing engines; utilization of furnace gases; treatment of flue dust; heat balance of the operation of a blast-furnace; the manufacture of steels by the basic and acid bessemer, basic

and acid open-hearth, crucible, and electric furnace methods; the manufacture of wrought iron; the constitution and structure of iron and steel; heat and mechanical treatment of steel; foundry practice; uses of steel products; and the study of special steels.

Prerequisites: General Metallurgy 39a.

Required in II., V. and VI.

Junior year, second semester, three hours a week. Credit three hours.

Texts: Stoughton, *Metallurgy of Iron and Steel.*
Sauveur, *Metallography of Iron and Steel.*
Carnegie, *Liquid Steel.*
Howe, *Iron, Steel, and Other Alloys.*
Richards, *Metallurgical Calculations, Vol. II.*

44b. ALLOYS AND METALLOGRAPHY. *Laboratory.*
(Clayton)

This course is intended for men wishing to specialize in iron and steel.

Prerequisites: Chemistry 7a, Metallurgy 29b and 41b.

Senior year, second semester, nine hours per week. Credit four and one-half hours.

46b. ORE DRESSING PROBLEMS. *Laboratory.*
(Mann)

This covers a portion of the work given in Metallurgy 34b. It is intended for students wishing to spend a limited amount of time in mill designing.

Prerequisites: Metallurgy 1b, 2b and 33a.

Shop Practice and Drawing 2b. To be accompanied by Metallurgy 33a and 33b.

Senior year, second semester, three hours per week. Credit one and one-half hours.

METALLURGY AND ORE DRESSING.

MINE TUNNEL.

MINING

Professor Forbes, Mr. Barton, Mr. Stoner.

Equipment.

The mining lecture room, located on the first floor of Norwood Hall in the southwest corner of the building, is provided with a combination lantern, reflectoscope and moving-picture machine. The school has several hundred lantern slides of mining scenes and mining machinery, and motion films showing mining operations are obtained from the U. S Bureau of Mines. Three rock drills in section, supported on a suitable frame, are kept in the classroom together with exhibits of explosives, rock-drill bits, wire ropes, safety lamps, mine-rescue apparatus and various other mining appliances.

A number of models illustrating mining methods, head frames, mine timbering, skip dumps, reversible mine fan, methods of locating drill holes in tunneling and rotary drill for coal mining, are on display in the mining laboratory and are used in connection with the lecture work.

The surveying equipment, already referred to under Civil Engineering, includes a number of mining transits with auxiliary telescopes which are used for the field work in mine surveying.

Laboratories.

To meet the needs of some of the more important phases of mining work four laboratories have been equipped as follows:

Mine-Rescue and First-Aid Laboratory.

In accordance with the safety-first movement that has been making such rapid strides in the last few years, it has been deemed advisable to establish a mine-rescue and first-aid laboratory, where instruction is given in the use of breathing apparatus and in first aid to the injured. The equipment consists of three helmets, including a Draeger, Fleuss and Westfalia, a pulmotor, and all necessary first-aid supplies and charts. The time devoted to this laboratory does not exceed one afternoon a week for six weeks, but this is sufficient to familiarize the student with mine-rescue apparatus and to give him a fair knowledge of the principles of first aid.

Rock-Drilling Laboratory.

On account of the importance of rock drilling in metal mining operations, and also because it can readily be carried on in the laboratory, much stress is laid on this branch of the work, for which the following equipment is used: Piston drills: Ingersoll-Rand 2¼-inch auxiliary-arc-tappet drill; Ingersoll-Rand C-110 Butterfly; Sullivan 2¾-inch tappet; Sullivan 2¼-inch differential valve, with steam and air front heads; Sullivan FF-12 with water attachments; Wood 2¼-inch spool-valve. Hammer drills: No. 7 Water Leyner; Stopers: Waugh 16-V; Sullivan DA-21 with reverse feed; Hand Hammer drills: Ingersoll-Rand Jack-hammer; Hardsoeg; Cleveland; Ft. Wayne electric drill.

This equipment has been purchased from time to time as improvements have been made by the manufacturers, and although not complete, embraces most of the different types of air drills in use at present.

For the work of drilling, large blocks of red granite about 4x4x5 feet are imported from Southeast Missouri. Two drilling frames for supporting the machines on column and arm have been constructed—one under cover in a frame building, and the other out of doors.

For sharpening steel, besides the usual hand tools, there is a Leyner-Ingersoll 5-A sharpener with a complete assortment of dies and dollies for forming various-shaped bits, including the cross, X, Z, bull, five-point, six-point, eight-point, high-center and single and double-chisel bits, as well as parts for shanking Leyner, Jack-hammer and piston steels.

The work done in this laboratory consists in sharpening steel both by hand and with the sharpener, and in drilling with the various machines. No attempt is made to drill a great number of holes, but the work consists in measuring cutting speeds with different bits and air pressures, noting variations in length and number of strokes under varying conditions and measuring air consumption. For this purpose a Sullivan air meter is used, and an electrical device designed at the school is used for counting the number of blows of the drills.

The amount of time spent in the laboratory does not exceed three hours a week or one laboratory period for one semester in the regular course, but much use is made of it in thesis and experimental work.

Compressed Air Laboratory.

The use of compressed air is so important in mining operations that the school has deemed it advisable to equip this laboratory with apparatus that would be suitable not only for students' use, but also for purposes of research and investigation.

A Sullivan WB-2 straight-line air compressor of 290 cubic feet capacity supplies air for this laboratory as well as the rock-drilling laboratory, and a Laidlaw-Dunn-Gordon compressor, used by the school in pumping from a deep well, is in the same building and furnishes a different type for study.

Two large displacement tanks 15 feet high and 5 feet in diameter are used for making accurate measurements of air for the determination of orifice coefficients and various other experiments. Another interesting installation in this laboratory is a mine fan. This is a 36-inch single-inlet "Sirocco," directly connected to a 35 h. p. variable-speed motor, and has a capacity of 20,000 cubic feet per minute against a 4-inch water gauge. Two styles of runners with vanes at different angles are provided for experimental work. The fan is used in the regular laboratory work, where its efficiency is determined under varying conditions, and also for experimental work in air measurements, and the standardization of large orifices.

Mine Plant.

The mine plant is situated about one and one-half miles from the school, which was the nearest point available where rock of a suitable nature could be found. A tunnel is being driven into the hillside as shown in the engraving. The rock is a pitted dolomite.

The power plant for running the machine drills used in the tunnel consists of a 50 h. p. Erie fire-tube boiler and an Imperial type 10 Ingersoll-Rand air compressor of 100 cubic feet capacity. Water for the boiler is pumped from a near-by stream with a centrifugal pump driven by a 3 h. p. Ferro, two stroke per cycle, gasoline engine. A 5x7 Davis and Rankin steam engine and a 3.6 kw. 110-volt United States dynamo furnishes electricity for lighting the plant and for operating an electric drill. This unit has an interesting historical value. In 1892 it furnished all the power for the shop and for the dynamo laboratory, which were then located in the basement of the Rolla building.

In designing the power plant, an endeavor was made to introduce as great a variety of machinery as possible, as the operation of the plant is considered one of the most valuable features of this work.

The total time spent in the mine-plant laboratory is about the same as in the rock-drilling laboratory, but instead of working the usual three-hour period, from nine to twelve hours are put

in at a time, as a three-hour period is entirely too short for this kind of work.

The work is largely experimental, and consists in using different explosives and analyzing their products of combustion; trying out different methods of placing holes for blasting and different methods of setting off blasts; time studies of drilling operations are made, and cost-records of the work are required. In addition to this, the work of sharpening steel, timbering, mucking, track laying and hand drilling, together with the experience of running the power plant, affords a greater variety of work than can ordinarily be had in a reasonable length of time in practice. It is not the aim in this work to make drill runners or miners out of students, but to give them a greater familiarity with mining tools and methods than is obtainable from books or mere observation.

3a. MINING. *Lectures.* (Forbes)

A study of rock excavation, incuding rock drilling, explosives and blasting, supporting excavations, tunneling and shaft-sinking. Written reports are required on each subject as completed.

Prerequisites: Mechanical Drawing 2b, Physics 1a.

Required in I. and III.

Junior year, first semester, three hours per week. Credit three hours.

Texts: Young, *Elements of Mining.*
Foster, *Ore and Stone Mining.*
Donaldson, *Shaft Sinking.*
Weston, *Rock Drills.*
Current Technical Journals.
Publications of U. S. Bureau of Mines.

5b. MINE SURVEYING. *Lectures.* (Forbes)

The theory and practice of mine surveying are presented by lectures. The methods of carrying azimuth underground under different conditions are studied in detail, including shaft plumbing and the use of the auxiliary telescope. Notes of a complete mine survey are given the student, from which all calculations must be made and maps drawn. Other problems involving the strike and dip of veins are introduced, including the determination of intersection of veins, length of tunnels to intersect veins at depth, and the determination of strike, dip and thickness of veins from borehole data.

Prerequisite: Civil Engineering 2a.

Required in I.

Junior year, second semester, two hours per week. Credit two hours.

Text: Durham, *Mine Surveying.*

6b. MINE SURVEYING. *Problems.* (Forbes, Risher)

One afternoon per week is devoted to the solution of problems in mine surveying and to making mine maps.

Prerequisite: Must be accompanied by Mining 5b.

Required in I.

Junior year, second semester, three hours per week. Credit one and one-half hours.

11b. MINING. *Lectures.* (Forbes)

This is a continuation of the work of the Sophomore year, and includes the study of mining methods, sampling and estimation of ores, mine valuation, and a study of mining costs. The principles of mining law are also reviewed.

Prerequisites: Mining 3a, Geology 9a.

Required in I.

Senior year, second semester, three hours per week. Credit three hours with senior trip; two and one-half hours without trip.

Texts: Hoover, *Principles of Mining.*
Finlay, *The Cost of Mining.*
Current Technical Journals.

12. SENIOR TRIP. (Forbes)

During the second semester of the Senior year, a two weeks' trip is taken to Joplin or to St. Louis, Flat River, and other points in the southeast Missouri lead district, for the purpose of studying mining, ore dressing, smelting, geology, and power plants of these districts. Several days are devoted to practical work in mine surveying during which time a complete survey and map of some portion of a mine is made.

Required for graduation in Curricula I.

13b. MINE VENTILATION. *Lectures.* (Forbes)

A study of the various gases met with in mines, their origin, effects and detection; the amount of fresh air required for men and animals under varying conditions; natural and artificial means of ventilation; gas and dust explosions, and mine-rescue work. A large part of the course is devoted to problems in mine ventilation.

Prerequisites: Mining 3a and Physics 3a.

Senior year, first semester, three hours per week. Credit three hours.

16a. MINING LABORATORY. (Forbes, Barton)

Laboratory work in rock drilling and blasting, timbering, sharpening steel, track-laying, and operation of mine power plants. Reports are required on all work. A study of mine-rescue apparatus and first aid to the injured is included in this course.

No credit will be allowed in mining laboratory except in Curriculum I.

Prerequisite: Must be accompanied by Mining 3a.

Required in I.

Junior year, first semester, three hours per week. Credit one and one-half hours.

16b. MINING LABORATORY. (Forbes, Barton)

A continuation of the laboratory work of the Junior year. A feature of this work is the keeping of accounts and cost records of tunnel driving as a training in the study of mine accounting.

No credit will be allowed in mining laboratory except in Curriculum I.

Prerequisites: Mining 3a, 16a; Civil Engineering 27a; must be accompanied by Mining 17b.

Senior year, second semester, three hours per week. Credit one and one-half hours.

17b. MINING CONFERENCE. *Lectures.* (Forbes)

The conference consists in discussions relative to the mining laboratory work and lectures on mine accounting and bookkeeping. Reports are prepared by the student on various assigned subjects and presented to the class.

Prerequisites: Must be accompanied by Mining 16b.

Senior year, second semester, one hour per week. Credit one hour.

19b. MINING ECONOMICS. *Lectures.* (Forbes)

Various economic problems of interest to mining engineers are studied. The influence of mining in the history of America and especially in United States history is reviewed and the relation of mining to other industries is considered. The organization of the mining industry, the conservation of the mineral resources, and various problems in economics, including mining labor, wages, capital, taxation, profit-sharing, and employers' liability are presented by lectures and assigned reading.

Prerequisites: Mining 11b, Geology 9a.

Graduate course, first semester, one hour per week. Credit one hour.

20a, 20b. MINE PLANT DESIGN. *Laboratory.* (Forbes)

This is a drafting-room course and is supplementary to all the previous mining courses. Each student is required to prepare complete drawings for the equipment of a given mine. Bills of material, specifications, and complete estimates are submitted.

Prerequisites: Mining 11b and Civil Engineering 15a.

Graduate course, first and second semesters, six hours per week. Credit six hours.

23a. MINING LAW. *Lectures.* (Forbes)

A study of the mineral land laws of the United States and laws affecting the operation of mines, including workmen's compensation acts.

Prerequisites: Completion of the Junior year in Curriculum I.

Senior year, first semester, one hour per week. Credit one hour.

25b. OIL AND GAS. *Lectures.* (Forbes)

A study of well-drilling and oil-production methods.

Prerequisite: Geology 17a.

Senior year, second semester, one hour per week. Credit one hour.

Text: Paine and Stroud, *Oil Production Methods.*

38. JUNIOR TRIP.

At the end of the school year the members of the Junior Class take a three weeks' trip to Colorado and Utah, or other mining districts. The purpose of the trip is to give an opportunity for the study of the geology, mining, and concentration of ores in the districts visited.

Credit may also be obtained for this trip in the following manner:

The student may obtain employment at any mine, mill, or smelter of his own selection, for a period of not less than six weeks. This work will be accepted as a substitute for the regular trip only when accompanied by a suitable report on the mining, metallurgy, and geology of the district in which he is employed. Outlines of these reports will be furnished by the various departments. Affidavits will be furnished the students, to be signed by the mine or mill officials by whom he was employed, stating the time of such employment and nature of work.

Credit will be given for this course only to candidates for degrees of B. S. in Mining or Metallurgy.

Prerequisites: Mining 5b, Geology 3b, and Metallurgy 31b.

Required in I.

Junior year, Summer session.

PHYSICS AND ELECTRICAL ENGINEERING

Professor McRae, Mr. Frame, Mr. Duffy, Mr. Zeuch.

Equipment.

The lecture room and laboratories for Physics and Electricity are in Norwood Hall. The lecture room will seat one hundred students and is provided with water, gas, and electric connections for conveniences in lecture demonstrations and experiments.

The physical laboratory is on the ground, or basement, floor. There are two large laboratories, one equipped for general physical measurements in mechanics, sound, and heat, and one equipped for electric measurements. There is a battery room equipped with both primary and secondary batteries connected by wire with the various laboratories and the lecture room; a constant-temperature room with double walls and air space insulation; a commodious dark-room with blackened walls for spectrometric and photometric measurements, and a special laboratory for research work.

The equipment includes a Rowland electro-dynamometer with shunts and resistances; a Leeds and Northrup standard potentiometer with shunts and voltage coils; a Leeds and Northrup decade wheatstone bridge; a Queen post office pattern wheatstone bridge; a Leeds and Northrup ohmmeter; various wheatstone bridges and resistance boxes; standards of resistance and inductance; paper and mica condensers; various tangent, mirror, and ballistic galvanometers; a Duddell thermo-galvanometer; a Dolezalek quadrant electrometer; a Lummer-Brodhun photometer; a Bunsen photometer; a Gaetner dividing engine with linear and circular attachments; a Threlfall micro-manometer; a Dietzgen anemometer; a ten-inch induction coil; Crookes tubes; cathode and X-ray tubes; a Van Hooten and Tenbroeck electrostatic machine; a wireless demonstration set; a Gaetner electroscope for radio-active measurements; a Schmidt & Haensch spectrometer; a Rowland diffraction grating; photographs of Rowland's normal solar spectrum; an Ives photograph of a Rowland grating; various balances; calorimeters; micrometers, calipers, together with apparatus for illustrating the principles of physics.

The steam laboratory equipment includes Parr and Roland-Wild coal calorimeters; Ellison throttling and evaporating moisture calorimeter; Peabody, and Schaeffer and Budenberg moisture

Calorimeters; General Electric Co., and Gebhardt portable steam flow meters; Hays, and Orsat flue gas apparatus; Crosby, Thompson, Robertson, Schaeffer and Budenberg, and American steam and gas engine indicators; Schaeffer and Budenberg continuous drum indicator; Amsler, Willis, and Keuffel and Esser planimeters; various indicating and recording steam gages; Crosby steam gage tester; Tycos portable pyrometer; three water meters; thermometers, manometers, tachometers, and speed counters; Prony end friction brakes.

The dynamo laboratory contains an assortment of direct current generators and motors, a General Electric double current generator for direct current and alternating current work, a single and a three-phase generator, an induction motor, a single-phase repulsion motor, a rotary converter, stationary transformers, three-phase to two-phase transformers, Cooper-Hewitt mercury converters, a General Electric electrolytic motor-generator set, a remote control starting box, testing instruments, which include a Weston laboratory standard voltmeter with multipliers; a Weston laboratory standard millivoltmeter with shunts; Kelvin electrostatic stationary and portable voltmeters; Weston portable ammeters and voltmeters; Weston portable milli-voltmeters with shunts, and milli-ammeters with resistances; Weston, Thomson, and Westinghouse portable direct current and alternating current voltmeters; Weston and Thomson portable watt meters; Westinghouse portable poly-phase wattmeter; Westinghouse portable single and polyphase watt-hour meters; Westinghouse portable voltmeters and ammeters with transformers; General Electric edgewise type alternating current voltmeters, ammeters and watt-hour meters, electrodynamometers; Grassot fluxmeter; portable resistance grids, inductance coils, and condensers.

The various electrical motors used for power purposes in the shops and laboratories are available for testing in addition to the machinery in the dynamo laboratory. The total electrical equipment includes thirty-five motors, varying in size from ½ h. p. to 35 h. p., with the aggregate rating of 225 h. p.

The power plant is also used for experimental purposes, and comprises a strictly modern and thoroughly equipped laboratory. The machinery available for testing purposes includes four 130-h. p. Heine safety boilers, one of which is especially equipped with openings in the setting for temperature and draft measurements in furnace, combustion chamber and flues; a 13 by 14 Erie Ball engine direct connected to a 75 kw. 220 volt D. C. Westinghouse generator; a 10 by 12 Ideal engine direct connected to a 50 kw. 220 volt D. C. Westinghouse generator; a 12 by 11 General Electric marine type engine direct connected to a 50 k. v. a. 220 volts, 60 cycle, three phase generator with direct connected exciter; a 10 kw. 220 volt Curtis steam turbo generator; a 9 by 14 Brownell engine

equipped with a rope friction brake; a 5 by 7 Davis and Rankin vertical engine equipped with a Prony brake; a 21-h. p. Otto four strokes per cycle gas engine belted to a General Electric 15 kw. 220 volt D. C. inter-pole generator, and to a two stage Worthington centrifugal pump; a 3-h. p. Ferro two strokes per cycle portable gas engine; a D. C. switchboard with a panel for each generator and two for distribution switches, equipped with a Tirrill voltage regulator, a Thomson recording watt-hour meter, circuit breakers for each generator, and the usual ammeters and voltmeter; an A. C. switchboard with voltmeter, ammeters, wattmeter, and watt-hour meter. The pneumatic equipment includes a Laidlow-Gunn-Gordon air compressor, a Rand Imperial air compressor, a Sullivan straight-line two-stage air compressor, a 72-inch ventilating fan, a 36-inch ventilating fan, a 60-inch Buffalo forge blower, an experimental fan capable of delivering 250 cu. ft. of air per second at six inches of water pressure, two cylindrical steel tanks 6 ft. by 15 ft. for measuring air by water displacement.

There is a complete steam and pumping plant at the experimental mine, where laboratory practice is also obtained.

Courses.

1b. GENERAL PHYSICS. *Lectures.* (Frame)

The work in general physics begins with the study of kinematics, statics, kinetics, and the mechanics of fluids. The term's work concludes with the study of heat, including an introduction to thermodynamics. Particular attention is paid to harmonic motion as the basis for the study of such subjects as sound, light, and alternating currents of electricity.

Prerequisites: To be preceded by or accompanied by Mathematics 9a, 11a and 11b.

Required in I., II., III., IV., V., VI. and VII.

Sophomore year, second semester, four hours per week. Credit four hours.

Text: Duff, *A Textbook of Physics.*

In 1917-18 this course will be 1a, sophomore year, first semester, three hours per week.

2b. GENERAL PHYSICS. *Laboratory.* (Frame, Zeuch)

The laboratory is quantitative and aims, as far as possible, to instruct the student in the methods of physical measurement and the derivation of relations between the quantities measured. Emphasis is laid upon the derivation of physical laws rather than the verification of them.

Prerequisite: Mathematics 7b.

Required in I., II., III., IV., V., VI. and VII.

Sophomore year, second semester, three hours per week. Credit one and one-half hours.

In 1917-18 this course will be 2a, sophomore year, first semester.

3a. GENERAL PHYSICS. *Lectures.* (Frame)

This is a continuation of course 1b and includes the study of electricity and magnetism, sound and light. Particular stress is laid upon electrical potential, resistance, and impedance, and upon the reflection, refraction, and interference of waves. Lectures, illustrated by experiments, and recitations.

Prerequisites: To be preceded by or accompanied by Mathematics 9a and 11a.

Required in I., II., III., V., VI. and VII.

Junior year, first semester, four hours per week. Credit four hours.

Text: Duff, *A Textbook of Physics.*

In 1917-18 this course will be 3b, sophomore year, second semester, three hours per week.

4a. GENERAL PHYSICS. *Laboratory.* (Frame)

The work in the laboratory deals with the subjects studied in Physics 3a and the method is the same as that outlined in Physics 2b.

Prerequisite: To be accompanied by Physics 3a.

Required in I., II., III., V., VI. and VII.

Junior year, first semester, three hours per week. Credit one and one-half hours.

In 1917-18 this course will be 4b, sophomore year, second semester.

7a, 7b. PRINCIPLES AND PRACTICE OF ELECTRICAL ENGINEERING. *Lectures.* (McRae)

This course discusses the magnetic circuit of dynamos and motors, methods of testing and connections for operation of direct current dynamos and motors, of single and polyphase alternating current generators, of induction and synchronous motors, of stationary transformers and rotary converters, and the effects of frequency, resistance, inductance and capacity upon the impedance of alternating current circuits. During the latter part of the course the design of electrical transmission lines is studied, accompanied by the analytical and graphical solution of practical problems.

Prerequisites: Physics 1b and 3a.

Senior year, elective, first and second semesters, three hours per week. Credit six hours.

Texts: Gray, *Principles and Practice of Electrical Engineering.*
Pender, *Principles of Electrical Engineering.*

8a, 8b. DYNAMO LABORATORY. (McRae)

This course accompanies course 7a, 7b, and consists of calibration of instruments, measurements of ohmic and reactive resistances, insulation resistance and dielectric strength, regulation and efficiency tests, of dynamos, motors, transformers, and converters.

Prerequisites: Physics 1b and 3a.

Senior year, elective, first and second semesters, three hours per week. Credit three hours.

9a, 9b. ELECTRICITY AND MAGNETISM. (Frame)

This course is designed as an introduction to the study of electricity and magnetism.

Prerequisite: Mathematics 3a.

Elective, first semester, lectures and recitations, five hours per week. Credit five hours.

Second semester, four recitations per week. Credit four hours.

Text: Timbie, *Elements of Electricity.*

10b. ELECTRICAL LABORATORY. (Frame)

This course includes elementary tests in electrical and magnetic circuits, measurements with ammeters, voltmeters and wattmeters, and practice in wiring, connecting up lamps, motors and transformers.

Prerequisite: Physics 3a or 9a.

Sophomore year, second semester, six hours per week. Credit three hours.

11a, 11b. ELECTRICAL MACHINERY. *Lectures.* (Frame)

During the first semester this course takes up a detailed discussion of armature windings. The second semester is given to the study of various types of control apparatus.

Prerequisites: Physics, 3a and 4a.

Required in V.

Senior year, first and second semesters, two hours per week. Credit four hours.

12a, 12b. ELECTRICAL MACHINERY LABORATORY.

(Frame)

This course accompanies 11a, and 11b, and consists of practice in armature winding and a study of control apparatus.

Prerequisites: Physics 3a and 4a.

Required in V.

Senior year, first and second semesters, three hours per week. Credit three hours.

13a, 13b. ALTERNATING CURRENTS. (McRae)

A continuation of Physics 7b and includes a rigorous analytical treatment of the subject as well as a study of the various practical applications in mining and metallurgy.

Prerequisites: Physics 7b and 8b.

Elective, first and second semesters, five hours per week. Credit ten hours.

Text D. C. and J. P. Jackson, *Alternating Currents and A. C. Machinery.*

Not given in 1916-17.

19b. ELECTRIC DISTRIBUTION. (Duffy)

This course brings before the student problems of location of power house, size of conductors and transformers, lightning arresters, costs of systems and wiring for lights and power.

Prerequisites: Physics 7a and 7b.

Required in VI.

Senior year, second semester, three hours per week. Credit three hours.

Not given in 1916-17.

21a. ELECTRIC RAILWAYS. (McRae)

The railway motor and auxiliaries; train performance; interurban railways, signal service; and estimated costs of the different parts of the system are gone into in this course.

Prerequisites: Physics 7a and 12b.

Required in V.

Senior year, second semester, five hours per week. Credit five hours.

PHYSICAL TRAINING

Associate Professor Dennie, Mr. Wagner, Mr. Kamp, Mr. Imlay, Mr. Nevin, Mr. Murphy, Mr. Bruce.

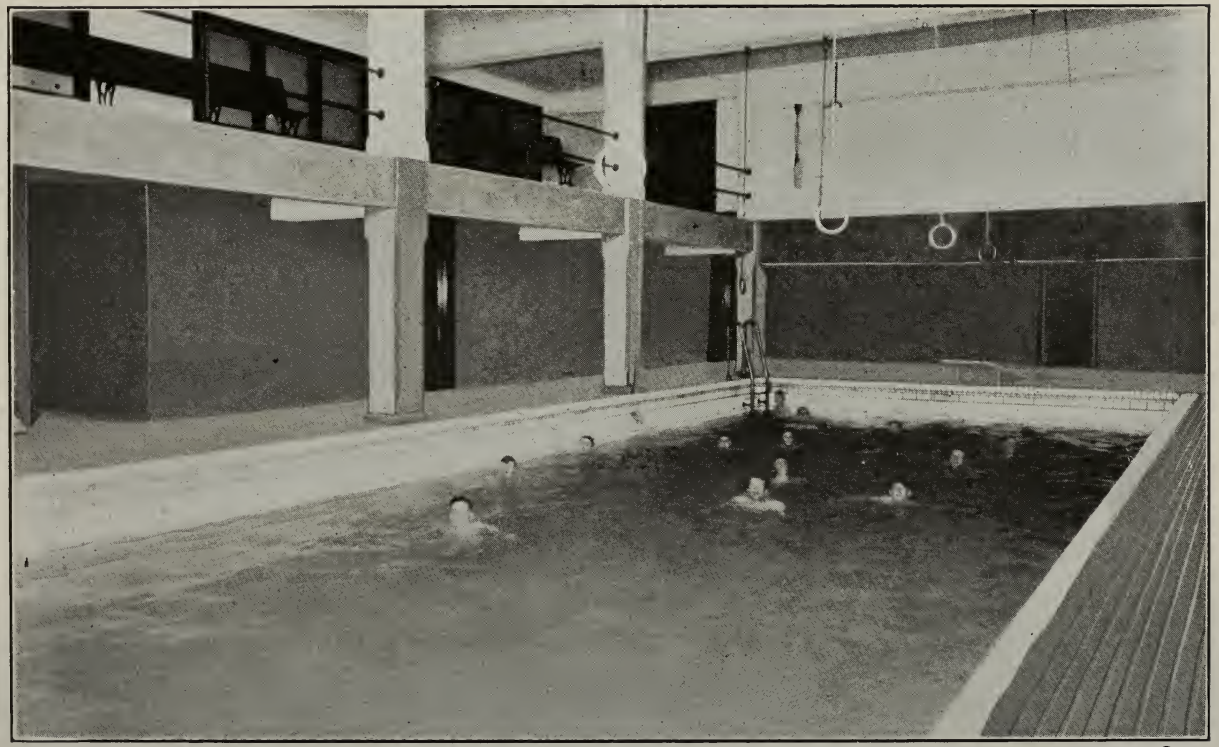
For the physical training of students excellent opportunities are offered by the Jackling Gymnasium and the Jackling Field. The former, completed in 1915, at a cost of seventy thousand dollars, is a strictly modern fireproof building and is equipped with baths, dressing rooms, lockers, a swimming pool 20 feet wide and 60 feet long and various kinds of apparatus and game courts usually found in modern gymnasiums. Class work, consisting of setting-up exercises, developing exercises, calisthenics, the use of dumb-bells, clubs, and wands is given under the supervision of the Professor of Physical Training. The aim of this work being to develop health, strength and vitality.

Jackling Field, constructed in 1909, by virtue of a gift of Mr. D. C. Jackling, '92, adjoins the gymnasium and provides a football gridiron, a baseball diamond, and a quarter-mile running track for class and intercollegiate games and events. A number of tennis courts about the campus are maintained in good order.

The School encourages rational athletics and a participation in intra and intercollegiate sport, all branches of which are under the direct supervision of the Professor of Physical Training and management of the Board of Control. The membership of the Board of Control consists of the Professor of Physical Training, the Chairman of the Faculty Committee on Athletics and the President and Student Manager of the Athletic Association.

The personnel of the Board of Control for 1916-1917: Professors F. E. Dennie and E. S. McCandliss, J. R. Nevin, '17, O. E. Stoner, '18, and Edw. Kahlbaum. Ex Officio Treasurer of the Athletic Association.

GYMNASIUM.



SWIMMING POOL.

EXCURSIONS

The State of Missouri occupies an important place in the mining industry, leading in the production of lead, zinc, cobalt, nickel, barite, and tripoli. Many opportunities are offered students at the School of Mines and Metallurgy for keeping closely in touch with the mining industry of Missouri and adjoining States. There have been many important developments during the last few years in methods of mining, dressing, and smelting lead and zinc ores. The lead district of Southeast Missouri and the zinc district of Southwest Missouri offer numerous examples of up-to date practice in mining and metallurgical engineering. The aggregate tonnage capacity of the concentrating plants of Missouri is greater than that of any other state of the Union. The importance of modern methods of ore dressing is everywhere recognized, and the facilities offered by the School of Mines for investigation in ore dressing, together with the practice in concentrating plants which are visited, places the School of Mines and Metallurgy in the foremost rank in this important branch of mine engineering.

During the summer the Junior class makes a trip to Colorado and Utah, visiting Denver, Idaho Springs, Central City, Georgetown, Silver Plume, Montezuma, Breckenridge, Leadville, Colorado Springs, Cripple Creek, Victor, and Pueblo in Colorado, and Salt Lake City, Garfield, and Bingham in Utah. Special attention is given to mining practice in the Clear Creek District, the Cripple Creek District, and Leadville and vicinity. Amalgamation is studied in the Clear Creek District, cyanidation at Colorado Springs and Victor; smelting of gold, silver, copper, and lead ores at Leadville and Pueblo; iron and steel metallurgy at Pueblo; treatment of zinc ores at Leadville.

Special attention is paid on these trips to general engineering problems, plant design, economy of operation, and organization.

During the Senior year a trip is made to the metallurgical plants in the vicinity of St. Louis. The plant of the St. Louis Blast Furnace Company illustrates blast-furnace practice. Here may be studied the blast-furnace, regenerative stoves, blowing machinery, power plant, and other appliances necessary for the production of pig iron. Open-hearth steel methods and the manufacture of steel castings are studied at the Scullin & Gallagher Works. This plant includes, in addition to the usual type of open-hearth furnace, Bessemer converters, cupolas, and gas-producers.

The metallurgy of zinc is studied at the Edgar Zinc Works at

Carondelet, where the roasting of blende and distillation methods may be seen. The Federal Smelter, at Alton, is visited for the study of lead smelting. At this plant the lead blast-furnace, the Huntington-Heberlin roasting system, and the Scotch ore-hearths are carefully inspected. This plant also includes an extensive bag house. The manufacture of white-lead paint and of lead pipe is seen at the National Lead Works. A further study of lead smelting is made at Herculaneum, where blast furnaces are served by Savelsberg pot roasters. At the various plants enumerated particular attention is paid to construction of furnaces, the operation of the plant, and the general organization and design.

The manufacture of refractory materials is carefully followed from the mine to the finished product at the plant of the Laclede-Christy Company. This plant is one of the largest clay manufacturing works in the world and a metallurgist here has a splendid opportunity to investigate refractory products and materials used in the construction of furnaces, stacks, retorts, and crucibles.

The class visits Southeast Missouri to study the geology, methods of mining, and the milling of great disseminated lead deposits. The geological work of this trip is especially valuable because of the variety of work introduced. The class has an opportunity to study several varieties of pre-Cambrian rocks of igneous and other origin. Differentiation in magma and intrusions can be seen. The pre-Cambrian topography is discernible in relation to the contact plane between the pre-Cambrian and the Cambrian. Evidence of superimposed drainage is offered. Iron ores of Shepard Mountain, Pilot Knob, and Iron Mountain give interesting study in the distribution and origin of ores. The general relation of the lead ores of the Paleozoic is also studied. The weathering of various kinds of rock in conjunction with jointing and stratification is well illustrated.

The concentration plants of Southeast Missouri are large and modern, containing crushers, rolls, elevating machinery, Wilfley tables, Frue vanners, jigs, and sundry other machines. The mining plants are thoroughly modern and include steam and electric hoists, modern steel head-frames, compressed air and electric haulage, extensive pumping plants, and numerous diamond-drill prospecting equipments.

In Southwest Missouri the geology, mining and milling of the shallow deposits as well as of "sheet" ground are studied by the Seniors. Opportunity is given to inspect and study the various types of equipment and methods as adapted to shallow and deeper mining. Many new concentrating plants have been erected and are strictly modern in design and equipment. The application of electrical power to mining and milling is well illustrated in this district. Short trips are made to neighboring camps in Southwestern Kansas.

GENERAL INFORMATION

Fraternities.

There are four Greek-letter college fraternities, each maintaining a chapter house: Gamma XI of Sigma Nu, Beta Alpha of Kappa Alpha, Beta Chi of Kappa Sigma, and Alpha Kappa of Pi Kappa Alpha. The engineering scholarship fraternity, Tau Beta Pi, established its Missouri Beta chapter in the School in 1908; and in 1916 the professional engineering fraternity, Theta Tau, installed its Iota chapter.

Y. M. C. A.

The organization this year has had a membership of 148. It stands for the best there is in college life and brings together those who believe that college men should develop well-rounded characters, physical, mental, and spiritual. During the opening days of the college the members of the Association devote themselves to the very practical service of meeting new men at the trains, helping them to secure living quarters, and aiding them in getting a good start in school. The Association occupies commodious and well-appointed quarters on the first floor of Parker Hall, where all students are welcomed and where the regular meetings are held.

The officers of the Association for 1915-1916 are:
H. A. Horner, 1917..... *President.*
C. W. Hippard, 1917..... *Vice-President.*
C. L. Epperson, 1918..... *Secretary and Treasurer.*

The Missouri Mining Association.

The objects of the Mining Association are: To advance the knowledge of mining among its members; to promote good fellowship among the students and alumni of the School of Mines and others interested in mining; and to bring the School into closer relation with the mining profession at large. Students in the School of Mines who have eighty-five credit hours on their course and alumni are eligible to membership.

This association is affiliated with the American Institute of Mining Engineers, and any member of it may become a junior member of the Institute. Such membership carries with it most of the privileges of regular membership at about one-half of the cost and with no initiation fee.

Twenty-nine members of the Missouri Mining Association are members of the American Institute of Mining Engineers. The total membership of the American Institute of Mining Engineers is over 5,000, one-fortieth of whom are Missouri School of Mines and Metallurgy men.

Officers of the Association for the year 1916-1917 are:

M. F. Bowles, 1917 ..... *President.*
R. O. Shriver, 1917 ..... *Vice-President.*
H. T. Herivel, 1918 ..... *Secretary.*
R. P. Lyons, 1918 ..... *Treasurer.*

Student Council.

The Student Council has for its object the promotion of various student enterprises and activities, and the maintenance of a spirit of mutual confidence in the student body and the faculty. The Council is composed of representatives of the four classes, with whom a committee of the faculty meets in an advisory capacity.

The representatives of the classes for 1916-1917 are:

Seniors—J. S. Brown, C. W. Hippard, R. O. Shriver, J. K. Walsh.

Juniors—P. D. Kern, W. H. Reber, M. Shanfeld.

Sophomores—J. W. Scott, C. C. Wilson.

Freshmen—J. H. Klyman.

Faculty—L. E. Garrett, F. E. Dennie, J. C. Ingram, W. H. Risher, C. R. Forbes.

Athletic Association.

The object of the Association is to unite the various efforts of the School in athletic sports. All students pay an athletic fee of five dollars a semester, which entitles them to membership in the Athletic Association, to admission to all athletic contests held under the auspices of the Athletic Association, and to gymnasium privileges. Members of the Faculty may become members of the Association by the payment of the stipulated fee. The Association elects its own officers and has general charge of all school athletics. The financial affairs of the Association are handled by a Board of Control. See page 132.

The officers of the Association for 1916-1917 are:

J. R. Nevin ..... *President.*
J. G. Reilly ..... *Vice-President.*
G. E. Ebmeyer ..... *Secretary.*
Edw. Kahlbaum ..... *Treasurer.*
O. E. Stoner ..... *Business Manager.*
E. N. Murphy ..... *Cheer Leader.*
W. Crow ..... *Assistant Cheer Leader.*

The Rollamo.

The Rollamo, first published in 1907 by the fraternities, is now edited by a staff chosen from the entire student body. The publication is the official yearbook of the school, and chronicles in permanent form the activities of the school year. The Board maintains a lyceum course and moving-picture shows, the proceeds of which help to defray the expenses of the publication:

The Board for 1916-1917 consists of the following:

J. K. Walsh ..... *Editor-in-Chief.*
O. E. Stoner ..... *Associate Editor.*
H. W. Doennecke ..... *Associate Editor.*
E. R. Housholder ..... *Art Editor.*
J. H. Bock, Jr ..... *Athletic Editor.*
W. C. Zeuch ..... *Staff Photographer.*
H. A. Ambler ..... *Business Manager.*
H. A. Kluge ..... *Asst. Business Manager.*
M. F. Bowles ..... *Advertising Manager.*
J. S. Brown ..... *Secretary.*
H. S. Clark ..... *Treasurer.*

The Missouri Miner.

The Missouri Miner is a weekly publication and was established in 1914-1915. It records the news of each week of interest to the student body and to the Alumni. It has been adopted as the official organ of the Alumni Association.

The officers for 1916-1917 are:

G. E. Ebmeyer ..... *Editor.*
J. K. Walsh ..... *Associate Editor.*
C. W. Hippard ..... *Assistant Editor.*
F. H. Geib ..... *Local Editor.*
G. D. Clayton ..... *Exchanges.*

M. L. Terry ..... *Business Manager.*
H. W. Doennecke ..... *Asst. Business Manager.*
W. Crow ..... *Advertising.*
W. Scott ..... *Assistant Advertising.*
W. H. Reber ..... *Circulation.*
O. Goldsmith ..... *Assistant Circulation.*

T. P. F. Walsh ..... *Senior Class.*
T. L. Dawson ..... *Junior Class.*
F. Deckmeyer ..... *Sophomore Class.*
C. B. Hummel ..... *Freshman Class.*

The Alumni Association.

In September, 1915, a move was inaugurated to organize an alumni association. After a preliminary nomination and election of officers, this association came into definite form on October 25, 1915. It has for its purpose the bringing together of the Alumni in closer relation with each other and their Alma Mater. All graduates, ex-students who have spent one year at the school, and present and former members of the faculty, are eligible to membership. Notices of the proceedings of the Association will be published in the Missouri Miner, and it is, therefore, recommended that all members of the Association subscribe for this publication. The Association will from time to time promote the interest of the School and its former students by establishing Alumni Clubs in the various centers. Three of these clubs have already been formed as follows:

Kansas City Alumni Club.

The Alumni of the School of Mines and Metallurgy living in and adjacent to Kansas City met in the banquet room of the Kupper Hotel February 6, 1915, and organized a Kansas City Alumni Club.

The officers for 1916-1917 are:

President.....R. R. Benedict, '08, Park Board, Kansas City.
Secretary.....H. W. L. Porth, '11, care of Swift & Co., Packers' Station, Kansas City, Kan.

St. Louis Alumni Club.

Former students and alumni living in and near St. Louis organized a St. Louis Alumni Club January 29, 1916.

President.....Kurt V. Moll, 4445 Laclede Ave., St. Louis.
Secretary.....Robert Patrick Cummins, Frisco Bldg., St. Louis.

Joplin Alumni Club.

Former students and alumni of the School living in Joplin and adjacent territory organized the Joplin Alumni Club on December 29, 1915.

President.....E. W. Buskett, '95, 620 Joplin street, Joplin.
Secretary.....C. H. O'Neill, 511 N. Ball street, Webb City.

Officers of Alumni Association.

President.....W. Rowland Cox, 120 Broadway, New York, N. Y.
Vice-President..Ray F. Rucker, Aluminum Ore Co., East St. Louis, Ill.
Secretary.....Charles Y. Clayton, Rolla, Mo.

Advisory Committee.

George R. Dean . . . . . Rolla, Mo.
L. E. Garrett . . . . . Rolla, Mo.
Kurt V. Moll . . . . . 4445 Laclede Ave., St. Louis, Mo.
R. R. Benedict, Board of Park Commissioners . . Kansas City, Mo.
E. W. Buskett . . . . . 620 Joplin St., Joplin, Mo.
H. T. Mann . . . . . Rolla, Mo.

EXPENSES

Tuition Fee.

Tuition is free to all students who are residents of Missouri. At a meeting held in October, 1908, the Board of Curators voted that "From and after January 1, 1909, nonresidents of Missouri who matriculate in any Department of the University be required to pay a tuition fee of $20.00 per year."

Laboratory Fees.

The fees charged are as follows: An incidental and library fee of $5.00 a year, payable upon entrance; a laboratory fee in general chemistry to cover the cost of gas and supplies, $10.00 a semester; a laboratory fee in qualitative analysis of $10.00 a semester to cover the cost of general supplies and gas; a laboratory fee for quantitative analysis and Senior and Junior chemistry laboratory work, $2.00 a semester; a fee of $2.50 a semester to cover the cost of supplies for shop work; a fee of $2.50 a semester to cover the cost of fuel and supplies in forge work; a fee of $2.50 a semester to cover supplies in machine shop; a fee of $25.00 a semester to cover the cost of supplies and fuel in the assay laboratory; a fee of $5.00 a semester for metallurgical laboratory; a fee of $4.50 a semester for mineralogy laboratory; a fee of $2.50 for diploma; a gymnasium and athletic fee of $5.00 a semester.

Excursion Expenses.

The cost of field excursions will average about $50.00 a year. The total expenses of all trips in the four-year mining curriculum is about $200.00.

Contingent Deposits.

A deposit of $15.00 is required from each student to cover the cost of extra supplies and damage to apparatus. This deposit must be renewed if at any time exhausted, and at the end of the school year whatever sum may remain to the credit of the depositor is returned to him.

Annual Expenses.

The following is an estimate of the heaviest items of the student's expenses. As personal tastes vary widely, no estimate of total expenses is offered:

Room rent, nine months, $5.00 to $10.00 per month, average	$65.00
Board, thirty-six weeks, $4.00 per week, average	144.00
Fees, excluding tuition	55.00
Drawing instruments (first year) and books	25.00

FEES IN MINE ENGINEERING CURRICULUM

FRESHMAN YEAR.

First Semester.

Matriculation	$5.00
Contingent Deposit*	15.00
Tuition (free for Missouri students)	10.00
General Chemistry Laboratory	5.00
Shop Work	2.50
Athletic Fee	5.00

Second Semester.

Tuition (free for Missouri students)	$10.00
General Chemistry Laboratory	5.00
Forge	2.50
Athletic Fee	5.00

SOPHOMORE YEAR.

First Semester.

Matriculation	$5.00
Contingent Deposit*	15.00
Tuition (free for Missouri students)	10.00
Qualitative Analysis Laboratory	10.00
Mineralogy	4.50
Athletic Fee	5.00

Second Semester.

Tuition (free for Missouri students)	$10.00
Quantitative Analysis Laboratory	2.00
Mineralogy	4.50
Athletic Fee	5.00

*This is a deposit to cover extra supplies and breakage. An account is kept with each student and at the end of the school year whatever sum may remain to the credit of the depositor is returned to him.

JUNIOR YEAR.

First Semester.

Matriculation	$5.00
Contingent Deposit*	15.00
Tuition (free for Missouri students)	10.00
Quantitative Analysis Laboratory	2.00
Athletic Fee	5.00

Second Semester.

Tuition (free for Missouri students)	$10.00
Assaying 2b	25.00
Assaying 2a	18.00
Assaying 4b	10.00
Athletic Fee	5.00

SENIOR YEAR.

First Semester.

Matriculation	$5.00
Contingent Deposit*	15.00
Tuition (free for Missouri students)	10.00
Metallurgy Laboratory	5.00
Athletic Fee	5.00

Second Semester.

Tuition (free for Missouri students)	$10.00
Athletic Fee	5.00
Diploma Fee	2.50

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*This is a deposit to cover extra supplies and breakage. An account is kept with each student and at the end of the school year whatever sum may remain to the credit of the depositor is returned to him.

JACKLING LOAN FUND

Loans may be made to students of the School of Mines from the Jackling Loan Fund under the following conditions:

1. The student must have been in attendance at the School of Mines one semester.

2. Written requests for loans must be filed with the Director, to be considered at the following meeting of the Executive Committee.

3. Loans may be made to students who cannot give security, provided they present the endorsement of the Director of the School and a responsible party not connected with the School.

4. No loans of more than one hundred dollars may be made to any one student during the calendar year.

5. The student shall give his note for the amount of the loan, which note shall bear interest at the rate of five per cent per annum from the date of the note to one year after his graduation or his leaving the School of Mines, and for one year following at the rate of eight per cent per annum. The note shall then become due.

The purpose of the Jackling Loan Fund is to help worthy students who require financial assistance and who are unable to borrow money from other sources.

THE MINING EXPERIMENT STATION

Officers of the Station.

ALBERT ROSS HILL, Ph. D., LL. D. . . *President of the University.*
AUSTIN LEE MCRAE, S. D. . . . . *Director.*
GUY HENRY COX, Ph. D., E. M. . . . *Geology and Mineralogy.*
CARROLL RALPH FORBES, E. M. . . . . *Mining.*
VICTOR HUGO GOTTSCHALK, M. S. . . *Chemistry.*
HORACE THARP MANN, E. M. . . . . *Metallurgy and Ore Dressing.*
MARTIN HARMON THORNBERRY, B. S. *Research Assistant.*
FLOYD DIXIE JAMES. . . . . *Research Assistant.*
HOWELL SMITH CLARK. . . . . *Station Assistant.*

The Mining Experiment Station was established June 1, 1909.

It is the object of the Station to conduct such original researches or to verify such experiments as relate to the properties and uses of mineral products; to investigate the engineering problems connected with the mineral industry, the economic methods of mining and the preparation of mineral products, the methods of preventing waste of the mineral resources and the methods of preventing accidents in mines, mills, and smelters; to assist in improving the conditions surrounding the labor in mines, mills, and smelters; and such other researches or experiments as bear directly upon the application of mining and metallurgical engineering to the mineral industry of the State of Missouri.

Bulletins on "Cupellation Losses in Assaying," by H. T. Mann and C. Y. Clayton; "Geologic Criteria for Determining the Structural Position of Sedimentary Beds," by G. H. Cox and C. L. Dake; "Experiments from the Flotation Laboratory," by C. Y. Clayton; and "Studies on the Origin of Missouri Cherts and Zinc Ores," by G. H. Cox, Reginald S. Dean and V. H. Gottschalk have been issued during the year.

The Experiment Station is now working in co-operation with the State Geological Survey and the National Bureau of Mines on the milling and concentration of Missouri lead and zinc ores.

Any resident of the State may on request obtain bulletins as issued, or if particularly interested, may be placed on the regular mailing list. Correspondence regarding these bulletins or the work of the Station may be addressed to the Director, Mining Experiment Station, Rolla, Missouri.

BUREAU OF GEOLOGY AND MINES

The Geological Survey of the State of Missouri has its headquarters at Rolla, and occupies the Rolla Building on the School campus.

Board of Managers.

GOVERNOR FREDERICK D. GARDNER, Jefferson City,
President.
ELIAS S. GATCH, St. Louis,
Vice-President.
CLARK CRAYCROFT, Joplin,
Secretary.
EDWARD M. SHEPARD, Springfield,
Chairman of Publication Committee.
PHILIP N. MOORE, St. Louis.

Staff of the Geological Survey.

H. A. BUEHLER,
State Geologist.
STUART ST. CLAIR,
Geologist.
G. B. CORLESS,
Geologist.
M. E. WILSON,
Geologist.

Equipment and Investigations.

The Geological Survey has at the present time a library of approximately five thousand volumes and pamphlets on geological and allied subjects, and a museum of seven thousand specimens of clay, coal, barite, lead and zinc ore, iron ore, and other mine and quarry products of Missouri.

The Geological Survey is organized principally to aid in the development of the mineral resources of Missouri. Information concerning these resources is gathered through observations in the

field by members of the staff. Geologic and topographic maps are prepared of different parts of the State and the various formations are accurately described in accompanying reports. The relation of geology to the ore deposits is also worked out and detailed reports published concerning such investigations.

The Department has the following reports available for distribution at the present time:

Preliminary Report.....Vol. XIII.
Geology of Miller County.....Vol. I., 2d series.
Quarrying Industry of Missouri.....Vol. II., 2d series.
Geology of Moniteau County.....Vol. III., 2d series.
Geology of the Granby Area.....Vol. IV., 2d series.
Public Roads.....Vol. V., 2d series.
Lime and Cement Resources of Missouri....Vol. VI., 2d series.
Geology of Morgan County.....Vol. VII., 2d series.
Geology of Pike County.....Vol. VIII., 2d series.
Geology of the Disseminated Lead Deposits of St. Francois and Washington Counties..Vol. IX., 2d series.
Iron Ores of Misouri.....Vol. X., 2d series.
Coal Deposits of Missouri.....Vol. XI., 2d series.
Geology of the Rolla Quadrangle.....Vol. XII., 2d series.
The Stratigraphy of the Pennsylvanian Series of Missouri.....Vol. XIII., 2d series.

Theses Submitted in 1916.

A Study of the Stoping Efficiency and Ore Transportation of the Arizona Copper Company at Morenci, Arizona,
ROBERT STANLEY BURG.
Land Drainage in Central Iowa.....ERNST L. CHAMBERLAIN.
Oils and Flotation,
CHARLES YANCEY CLAYTON AND CLARENCE EUGENE PETERSON.
An Investigation in Treating a Gold Ore from Custer, South Dakota,
THEODORE SAUNDERS DUNN.
Report on the Lucky Bill Mine, Grant County, New Mexico,
WALTER GAMMETER.
Pneumatic Ore Concentration,
ROBERT WINTERS JOHNSON AND WALTER WILLIAM WEISSBACH.
Leaching Flue Dust.....EDWIN ALEXANDER KAYSER.
The Effect of Temperature Upon the Crystal Size and Physical Properties of Iron and Steel.....E. J. MCNELY.
The Development of a Copper-Silver Ore Body,
COLWELL ARBA PIERCE.
Notes on Mine Operations of the American Zinc Company of Tennessee.....HOMER KENT SHERRY.
A Report on La Cotabambas Auraria Mining Company,
HECTOR J. BOZA.

Underground Mining Methods of Utah Copper Company,
THOMAS S. CARNAHAN.
Leaching Experiments on an Arizona Copper Ore,
GUNNARD EDMUND JOHNSON.
Development of the Flotation Process for Concentrating Copper and Iron Sulphide Ores.....H. T. MARSHALL.
The Cost of Producing Electricity at the Hamilton, Missouri, Light and Power Plant.....BERNARD WILLIAM ADAMS.
Tars from Cannel Coal,
J. C. INGRAM, O. L. LUMAGHI AND F. GROTTS.
A Wet Process for the Recovery of Mercury,
ROBERT G. SICKLY.
Construction and Maintenance of Kansas City Boulevard Pavements.....R. R. BENEDICT.
Economic Design of Concrete Steel Highway Bridges,
T. P. MCCAGUE.
Method and Costs of Rock Excavation, Inlet Swamp Drainage District, Lee County, Illinois.....ARCH W. NAYLOR.
An Investigation in Portland Cement.....BYRON L. ASHDOWN.
Mining Methods at Calumet and Arizona Mining Company,
J. L. HEAD.
Comparison of Operating Expenses and Capital Expenditures of Two Different Types of Boiler Rooms Covering Extensions Expected During the Next Twenty Years.....G. H. BOYER.
Some Chemical Problems in Geology.....REGINALD SCOTT DEAN.
Flotation of a West Joplin Slime..J. S. HOFFMAN AND J. J. DOWD.
Comparative Tests of Hammer Drill Bits.....H. H. VOGEL.
Preliminary Report on the Property of The Ruby Copper Company.....C. A. PIERCE.
An Investigation in Portland Cement Concrete,
DON H. MORGAN.
The Determination of the Method for Milling a New Mexico Ore,
A. X. ILLINSKI.
Design of a Plant for Concentrating Phosphate Rock,
N. L. OHNSORG.
Problems in Flotation.....W. H. MCCARTNEY, JR.
Milling Experiments on a Western Ore,
H. E. KOCH AND E. B. WEIBERG.
Flotation of Zinc Carbonates and Silicates,
G. ERSKINE AND Y. KLEPEL.
A Study of a Certain Filled Sink Ore Deposit....A. Z. DUNHAM.
Design of a Concrete Steel Bridge over Dry Fork..E. V. DAMOTTE.

DEGREES CONFERRED IN 1916

COMMENCEMENT EXERCISES MAY 26, 1916.

Engineer of Mines.

George Hewitt Boyer, B. S. 1908.
Hector Boza, B. S. 1911.
Thomas Samuel Carnahan, B. S. 1904.
Homer Kent Sherry, B. S. 1912.
Theodore Saunders Dunn, B. S. 1910, M. S. 1914.

Metallurgical Engineer.

Charles Yancey Clayton, B. S. 1913.
Alexis Xavier Illinski, B. S. 1910.
Norman Lloyd Ohnsorg, B. S. 1910.
Robert Glenn Sickly, B. S. 1913.

Civil Engineer.

Ralph Robert Benedict, B. S. 1908.
Ernst Lorenz Chamberlain, B. S. 1909.
Arch Waugh Naylor, B. S. 1912.

Master of Science.

Reginald Scott Dean, B. S. 1915.

Bachelor of Science in Mine Engineering.

Robert Stanley Burg.
Earl George Deutman.
James Joseph Dowd.
Walter Gammeter.
Charles Berliand Gold.
James Lawrence Head.
John Stone Hoffmann.
Octavius Louis Lumaghi.
William Henry McCartney, Jr.
Holman Thompson Marshall.
John Charles Miller.
Harold Arthur Neustaedter.
Colwell Arba Pierce.
Carl Godfried Stifel.
George Edgar Ude.
Herman Herbert Vogel.
Walter William Weissbach.

Bachelor of Science in Metallurgy.

Gunnard Edmund Johnson.
Hugo Edward Koch.
Earl Joesting McNely.
Clarence Eugene Peterson.

Bachelor of Science in Civil Engineering.

Byron Lee Ashdown.
Emil Lucius Beyer.
Edward Victor Damotte.
Lewis Needham Hoppock.
Thomas Purcell McCague.
John Ralph Maher.
Don Hawk Morgan.
Edward Louis Sailer.
John Morris Schuman.

Bachelor of Science in General Science.

Bernard William Adams.
Azmon Thurman Dunham.
Frederick Grotts.
Greene Erskine.
Edwin Alexander Kayser.

SUMMER STUDENTS, 1916

Aid, Harry ..... *Gallatin, Mo.*
Anderson, Sidney Lorenzo ..... *Springfield, Mo.*
Bruce, Robert ..... *Wellington, Kan.*
Burkhart, Edgar Carl ..... *Macon, Mo.*
Clark, Howell Smith ..... *Kansas City, Mo.*
Crenshaw, John Renoir ..... *St. Louis, Mo.*
Ebmeyer, Gerard Ernest ..... *Lincoln, Nebr.*
Erskine, Wood Steel ..... *San Antonio, Tex.*
Golick, Tony Frank ..... *Canton, Ill.*
Gotsch, Oscar Henry, Jr ..... *St. Louis, Mo.*
Hansen, Kund Fabricius ..... *Copenhagen, Denmark.*
Kamp, Henry George ..... *St. Louis, Mo.*
Lang, Frederick Robert ..... *St. Louis, Mo.*
Larsh, Napolen Bonepart ..... *Union, Nebr.*
Lottmann, Walter Frederick ..... *St. Louis, Mo.*
McComb, William Randolph ..... *St. James, Mo.*
Moore, Frederick Vail ..... *Crystal City, Mo.*
Nolte, William John ..... *St. Louis, Mo.*
Oyler, William Ellsworth ..... *Lyndon, Kan.*
Petsch, Arthur Henry ..... *Lexington, Mo.*
Powell, William Clark ..... *Rolla, Mo.*
Schuman, Edwin Kaine ..... *Rolla, Mo.*
Scott, James Walter ..... *Rolla, Mo.*
Shore, Harold Frank ..... *Chillicothe, Mo.*
Tao, Hung Tao ..... *Chaotung, China.*
Weeks, Albert Lemont ..... *Arenzville, Ill.*

STUDENTS, 1916-1917

Graduate Students.

Alexander, Raphael Currier..... *Texhoma, Okla.*
B. S., '03, E. M., '06.
*Ambler, John Owen, B. S., '06..... *Douglas, Ariz.*
*Conover, Cairy C., B. S., '12..... *Springfield, Ill.*
*Cook, Paul Richardson, B. S., '07..... *Guayaquil, Ecuador, S. A.*
Duffy, Ralph Earl..... *Rolla, Mo.*
B. S. in E. E., '08, University of Missouri.
*Elbelt, William Henry, B. S., '12..... *Hurley, New Mex.*
Frame, Floyd Hill..... *Rolla, Mo.*
A. B., '12, Clark College.
*Hall, Clyde Willis, B. S., '14..... *Metcalf, Ariz.*
*Hall, William Simpson, B. S., '09..... *Miami, Ariz.*
*Hanley, Herbert Russell, B. S., '01..... *Kennett, Calif.*
*Hauenstein, Frederick..... *Fort Towson, Okla.*
A. B., 1900, Westminster, B. S., '03.
Hinsch, Van Buren, B. S., '09..... *Rolla, Mo.*
Ingram, John Charavelle, B. S., '13..... *Rolla, Mo.*
*Lozano, Germin Garcia..... *Mexico City, Mex.*
McCandliss, Edgar Scott..... *Rolla, Mo.*
B. S. in C. E., '09, Purdue University.
*Moses, Frederick Galloway, B. S., '14..... *Salt Lake City, Utah.*
*Wander, Ernest..... *East St. Louis, Ill.*

Seniors.

MINE ENGINEERING.

Barton, Joseph C..... *Montgomery City, Mo.*
Bock, James Henry, Jr..... *Muskogee, Okla.*
Brown, John Stafford..... *Milford, Mo.*
Cepeda, Miguel Leon..... *Gomez Palacio, Mex.*
Crawford, Thomas Ralph..... *Paola, Kan.*
Dale, Ralph..... *Herrin, Ill.*
Dolman, Phillips Brooks..... *St. Joseph, Mo.*
Fernandez, Arturo Cleofas..... *Monterey, Mex.*
Greenberg, David..... *Kirkwood, Mo.*
Guest, William..... *Wilburton, Okla.*
Henschel, Ramsey Coleman..... *Kansas City, Mo.*
Hippard, Clemence William..... *Belleville, Ill.*

*In absentia.

Hoo, Te Chun ..... *Hun San, Hunan, China.*
Kamp, William Henry ..... *St. Louis, Mo.*
Keenan, John Thomas ..... *Providence, R. I.*
Klepel, Yaro ..... *St. Louis, Mo.*
Kluge, Harry Albert ..... *Collinsville, Ill.*
Lesniak, Stanislaw Wojciech ..... *Rolla, Mo.*
Lucky, Maurice Cecil ..... *Cassville, Mo.*
Miller, Elton Arthur ..... *Edwardsville, Ill.*
Nevin, James Raymond ..... *Ottumwa, Ia.*
Pape, Paul Frederick ..... *Cape Girardeau, Mo.*
Reilly, John Henderson Gay ..... *St. Louis, Mo.*
Scheurer, Leroy Robert ..... *Wichita Falls, Tex.*
Shroer, Edward Albrecht ..... *Clayton, Mo.*
Shaw, William Allen ..... *St. Louis, Mo.*
Shayes, Frederick Pine ..... *Rochester, N. Y.*
Teets, Charles Wallingford ..... *Newton, Ill.*
Weimer, Earl Joseph ..... *Girard, Kan.*

METALLURGY.

Ambler, Harry Atwood ..... *St. Louis, Mo.*
Bowles, Martin Frady ..... *St. Louis, Mo.*
Elfred, Frank Stillman, Jr ..... *St. Joseph, Mo.*
Horner, Howard Andrew ..... *St. Louis, Mo.*
James, Floyd Dixie ..... *St. Louis, Mo.*
Thornberry, Martin Harmon, B. S., '12. ... *Rolla, Mo.*
Walsh, Thomas Patrick Francis ..... *St. Joseph, Mo.*

CIVIL ENGINEERING.

Eames, Frederick Lovett ..... *St. Louis, Mo.*
Heman, Frederick Richard ..... *Fort Dodge, Ia.*
Peterson, Carl Alden ..... *Schenectady, N. Y.*
Shipley, John Joshua ..... *Kansas City, Mo.*
Shriver, Ray Otto ..... *Newton, Kan.*
Teas, Howard Jones ..... *Freeport, N. Y.*
Wilson, George Baldwin ..... *Rolla, Mo.*

GENERAL SCIENCE.

Arnold, Emmett Lee ..... *Nevada, Mo.*
A. B., '14, Drury College.
Walsh, John Kennedy ..... *St. Louis, Mo.*
A. B., '14, St. Louis University.

MECHANICAL ENGINEERING.

Muehlberg, Clarence Elmer ..... *St. Louis, Mo.*

ELECTRICAL ENGINEERING.

Heimberger, Harry Tobias ..... *Rolla, Mo.*

Juniors.

MINE ENGINEERING.

Boyer, Ray Vernon ..... *Tarkio, Mo.*
Burnet, George ..... *St. Louis, Mo.*
Chavez, Raul ..... *St. Louis, Mo.*
Cooper, Richard Dwyer ..... *St. Louis, Mo.*
Corby, Harry Gilbert ..... *Carthage, Mo.*
Cunningham, Lorain Harry ..... *Columbus, Kan.*
Duga, Joseph Benjamin ..... *Bellaire, Ohio.*
Ebmeyer, Gerard Ernest ..... *Lincoln, Neb.*
Flanders, Jerome Emerson ..... *Paris, Mo.*
Geib, Francis Hodgson ..... *Denver, Colo.*
Herivel, Harold Tourtel ..... *El Oro, Mex.*
Hippard, Wesley George ..... *Belleville, Ill.*
Housholder, Earl Ross ..... *Bowling Green, Ohio.*
Kern, Paul Dean ..... *Monroe City, Mo.*
Lask, Harold Arthur ..... *Pasadena, Calif.*
Leonard, Speed Stephens ..... *Marshall, Mo.*
Lyons, Robert Paul ..... *Springfield, Mo.*
Maness, Orie Newell ..... *Webb City, Mo.*
Morris, John Munson ..... *Farmington, Mo.*
Murphy, Earle Nelson ..... *Vinita, Okla.*
Ore, Felipe Buenaventura ..... *Lima, Peru.*
Powell, William Clark ..... *Rolla, Mo.*
Raible, Joseph Christopher, Jr ..... *Hannibal, Mo.*
Reber, William Houston ..... *Dallas, Tex.*
Schnaidt, Charles Michael ..... *St. Louis, Mo.*
Sherwood, Theodore Clayton, Jr ..... *Kansas City, Mo.*
Skeen, Leslie Carlisle ..... *Big Stone Gap, Va.*
Stoner, Oscar Eli ..... *Chester, Neb.*
Valentine, Herman Frederick ..... *Marshall, Mo.*
Zoller, Lawrence Joseph ..... *Tulsa, Okla.*

METALLURGY.

Clark, Howell Smith ..... *Kansas City, Mo.*
Doeling, Victor Hugo ..... *Hannibal, Mo.*
Doennecke, Henry William ..... *Davenport, Iowa.*
Epperson, Charles Lee ..... *Joplin, Mo.*
Golick, Tony Frank ..... *Canton, Ill.*
Kaplan, Louis ..... *St. Louis, Mo.*
Pugh, James Willard ..... *Kansas City, Mo.*
Schiermeyer, Harry John ..... *St. Louis, Mo.*
Shanfeld, Michael ..... *St. Louis, Mo.*
Stahl, Horace Reynolds ..... *Quincy, Ill.*
Terry, Mark Loren ..... *Jamesport, Mo.*
Velasco, Rafael Esteban ..... *San Luis Potosi, Mex.*

CIVIL ENGINEERING.

Bardsley, Clarence Edward.....*St. Louis, Mo.*
Dawson, Thomas Langhead.....*Kansas City, Mo.*
Heimberger, Karl William.....*Rolla, Mo.*
Zeuch, Walter Charles.....*St. Louis, Mo.*

GENERAL SCIENCE.

Fiedler, John Ray.....*Shelbyville, Ind.*
Wilson, Eldred Dewey.....*Rolla, Mo.*

MECHANICAL ENGINEERING.

Cole, Joseph Bryant.....*Rolla, Mo.*
Mellow, Richard Wesley.....*St. Louis, Mo.*

CHEMICAL ENGINEERING.

Goldman, Leon Harrison.....*St. Louis, Mo.*
Kahlbaum, William.....*Rolla, Mo.*

Sophomores.

MINE ENGINEERING.

Aid, Harry.....*Gallatin, Mo.*
Alfend, Reuben.....*St. Louis, Mo.*
Anderson, Sidney Lorenzo.....*Springfield, Mo.*
Bates, Arle Haywood.....*Flat River, Mo.*
Benton, Louis Brent.....*Fort Worth, Tex.*
Beyer, Daniel Christopher.....*Long Island City, N. Y.*
Bohart, Philip Harris.....*Fort Worth, Tex.*
Brazill, Matthew Patrick, Jr.....*St. Louis, Mo.*
Bruce, Robert.....*Wellington, Kan.*
Burgesen, John Christian.....*Kansas City, Mo.*
Crow, Wayman.....*St. Louis, Mo.*
Decker, Ernest Ethridge.....*Waynesville, Mo.*
Dowd, Raymond John.....*St. Louis, Mo.*
Durning, William Clarence.....*St. Louis, Mo.*
Eulich, Artileus Vosteen.....*St. Joseph, Mo.*
Ewing, Harold Kline.....*Odessa, Mo.*
Farmer, Raymond Louis.....*Lebanon, Mo.*
Forman, Percy Grant.....*Rolla, Mo.*
Goldsmith, Osher.....*Dallas, Tex.*
Goodwin, George Gerald.....*Kansas City, Mo.*
Gotsch, Oscar Henry, Jr.....*St. Louis, Mo.*
Gray, William Douglas.....*New York City, N. Y.*
Hansen, Knud Fabricius.....*Copenhagen, Denmark.*
Harlowe, Leslie Steele.....*Covington, Ind.*
Hodges, Joseph Tipton.....*Granby, Mo.*

Hurd, Harold Waller.....*Paris, Mo.*
Larsh, Napolean Bonaparte.....*Rolla, Mo.*
Marston, Robert.....*El Paso, Tex.*
Miller, Galen.....*Joplin, Mo.*
Moore, Frederick Vail.....*Crystal City, Mo.*
Morris, Thomas Carson.....*Farmington, Mo.*
Niece, William Latchaw.....*Tulsa, Okla.*
Nolte, William John.....*St. Louis, Mo.*
Page, James Harold.....*Rolla, Mo.*
Petsch, Arthur Henry.....*Lexington, Mo.*
Pray, Donald Porter.....*Wellington, Kan.*
Pryor, George Willis.....*Bethany, Mo.*
Rice, Carl Clark.....*Rolla, Mo.*
Rodenbaugh, Elmer Sidney.....*St. Louis, Mo.*
Scott, James Walter.....*Rolla, Mo.*
Scruby, Horace Dwight.....*Chillicothe, Mo.*
Shore, Harold Frank.....*Chillicothe, Mo.*
Starkey, Alvah Chapman.....*San Diego, Calif.*
Stokes, Lawrence William.....*Kennett, Mo.*
Wilson, Clarence Chamberlin.....*Lexington, Mo.*
Wilson, Kenneth Campbell.....*Globe, Ariz.*

METALLURGY.

Deckmeyer, Frederick.....*St. Louis, Mo.*
Gill, James Pressley.....*Montgomery City, Mo.*
Leach, Thomas Witt.....*Pine Bluff, Ark.*
Lynn, Earl Albert.....*St. Louis, Mo.*
Oakleaf, Lovell Randal.....*Cherryvale, Kan.*
Potts, Allen Dewey.....*Pittsburgh, Pa.*
Scothorn, Carl William.....*Junction City, Kan.*
Weiser, Hanley.....*Webster Groves, Mo.*

CIVIL ENGINEERING.

Ashlock, Evan Earl.....*St. Louis, Mo.*
Harris, Harold Shelton.....*Morley, Mo.*
McCarthy, Merryl.....*Farmington, Mo.*
Williams, Anvil Clark.....*Sullivan, Mo.*

GENERAL SCIENCE.

Kerr, Arthur John.....*Rolla, Mo.*

ELECTRICAL ENGINEERING.

Beck, Stanley Ashton.....*Clifton, Ariz.*
Lottmann, Walter Frederick.....*St. Louis, Mo.*

CHEMICAL ENGINEERING.

Badollet, Marion Smith ..... *Vincennes, Ind.*
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Dorris, Charles Lester ..... *Collinsville, Ill.*
Krause, Frederick Arthur ..... *St. Louis, Mo.*
Lang, Frederick Robert ..... *St. Louis, Mo.*
Nichols, Benjamin Guthrie ..... *E. St. Louis, Ill.*
Oyler, William Ellsworth ..... *Marceline, Mo.*
Smiley, Vivien X. ..... *Hannibal, Mo.*
Wilkinson, Paul DeLassus ..... *St. Louis, Mo.*

Freshmen.

Ackers, Albert Louis ..... *Staunton, Ill.*
Bailey, Harold Leland ..... *Virginia, Ill.*
Barnard, Charles Russell ..... *St. Louis, Mo.*
Bloom, George Barnett ..... *Maysville, Mo.*
Cairns, Arthur Lee ..... *Cape Girardeau, Mo.*
Cameron, Campbell Robinson ..... *McAlester, Okla.*
Carson, William Thomas ..... *Alton, Ill.*
Casselman, Lawrence Owen ..... *Rolla, Mo.*
Charles, Beryl Elwood ..... *Saline, Kan.*
Clayton, George Dillard ..... *Hannibal, Mo.*
Conrad, John DeWitt ..... *Hamilton, Mo.*
Cox, Henry Cicero ..... *E. St. Louis, Ill.*
Crutcher, Welborn Ball ..... *Marshall, Mo.*
Czaderski, Maksymilian Josef ..... *Chicago, Ill.*
Davidson, Lewis Ely ..... *Savannah, Mo.*
Dickerson, Frederick Clair ..... *Salem, Mo.*
Donai, Willard Bartholomew ..... *Des Moines, Iowa.*
Dorris, Milburn Leo ..... *Collinsville, Ill.*
Duffy, Charles ..... *Greenfield, Mo.*
Dunlop, William Harry ..... *Beardstown, Ill.*
Elkins, Charles Edgar ..... *Dixon, Mo.*
Evans, John Raymond ..... *Chillicothe, Mo.*
Fenelon, Charles ..... *Chillicothe, Mo.*
Finlay, William James ..... *Webster Groves, Mo.*
Forgotson, James Morris ..... *St. Louis, Mo.*
Fox, George Howard ..... *Butler, Mo.*
Gettler, Carl Andrew ..... *Hannibal, Mo.*
Goolsby, Joseph Arthur ..... *Clifton, Ariz.*
Haase, Walter Stracke ..... *St. Louis, Mo.*
Hahn, Abner Decker ..... *Muscatine, Iowa.*
Haley, Ralph Alwood ..... *Carl Junction, Mo.*
Halligan, Charles Francis ..... *Union, Mo.*
Hammer, Bernard Eli ..... *Stanton, Mo.*

Hayes, Stanley Merton ..... *Wellsville, Mo.*
Hodges, Isaac ..... *Granby, Mo.*
Hollow, Edward John ..... *Cuba, Mo.*
Hoppock, Harland Hobart ..... *Lebanon, Mo.*
Howald, Arthur Mark ..... *Rolla, Mo.*
Howendobler, John Leslie ..... *Tulsa, Okla.*
Hume, Horace Catlett ..... *Waco, Mo.*
Hummel, Carl Bernard ..... *Kirkwood, Mo.*
Jackson, James Taylor ..... *Marion, Ind.*
Johnson, Edwin Charles ..... *Schenectady, N. Y.*
Johnson, Noah Purcell ..... *Vincennes, Ind.*
Johnson, Richard Love ..... *Henryetta, Okla.*
Johnston, Irvin Benson ..... *St. Louis, Mo.*
Jungk, Carl Frederick ..... *Wichita Falls, Tex.*
Keeler, William Weaver ..... *Tulsa, Okla.*
Kershner, Karl Kenneth ..... *St. Louis, Mo.*
Klyman, Julius Hart ..... *St. Louis, Mo.*
Kroenlein, George Alfred ..... *St. Louis, Mo.*
Laun, Albert Charles ..... *St. James, Mo.*
Lehman, Harold Wesley ..... *Weeping Water, Neb.*
McMillen, Frank Morris ..... *Branson, Mo.*
Mann, Marion Robert ..... *Gallatin, Mo.*
Meyer, John Harold ..... *Mountain Grove, Mo.*
Miller, John Gaines ..... *Marshall, Mo.*
Norville, Glen Smith ..... *Beardstown, Ill.*
Novak, Joseph, Jr ..... *St. Louis, Mo.*
Olson, Carl Nathan ..... *Galesburg, Ill.*
Owen, Luther Cecil ..... *Joplin, Mo.*
Place, Roscoe Nelvin ..... *Gallatin, Mo.*
Pope, Frederick Alexander ..... *Wheaton, Ill.*
Rackett, Gerald Franklin ..... *Chicago, Ill.*
Richmond, Wendell William ..... *Hannibal, Mo.*
Runge, Charles Adelbert ..... *Kirkwood, Mo.*
Sherman, Benjamin Edward ..... *Tahlequah, Okla.*
Slover, Edwin Allsop ..... *East Orange, N. J.*
Sour, Stanley Sylvian ..... *Rush, Ark.*
Sprigg, Simeon Norwood ..... *Marshall, Mo.*
Stanfield, Edwin R. ..... *Oronogo, Mo.*
Stroup, Robert Knox ..... *Quincy, Ill.*
Stubbins, John Russell ..... *Paris, Mo.*
Stubbs, Robert Newton, Jr ..... *Kirkwood, Mo.*
Taggart, William Miskey, Jr ..... *St. Louis, Mo.*
Taylor, Frank Huston ..... *Rolla, Mo.*
Tidd, Luzerne Maurice ..... *Webster Groves, Mo.*
Turnbull, Raymond Miles ..... *Schenectady, N. Y.*
Uthoff, Fred William ..... *St. Louis, Mo.*
White, Frederick Pope ..... *East St. Louis, Ill.*
Whitworth, Virgil Lee ..... *Nevada, Mo.*

Wills, Ronald Blair ..... *Evansville, Ind.*
Wright, Kenneth Maurice ..... *Kansas City, Mo.*
Zieseniss, Harry Wesley ..... *Rolla, Mo.*

SPECIAL STUDENTS.

Baker, William Frank ..... *Dorchester, Mass.*
Chappell, Prudence ..... *Rolla, Mo.*
Crenshaw, John Renoir ..... *St. Louis, Mo.*
Ehler, Otto ..... *Washington, Mo.*
Etem, Charles August ..... *Kansas City, Mo.*
Fast, Joseph Bernard ..... *Chicago, Ill.*
Fleming, James Taaffe ..... *St. Louis, Mo.*
Freudenberg, Walter Harry ..... *St. Louis, Mo.*
Gaffney, James ..... *St. Louis, Mo.*
Gerber, Clarence Oliver ..... *Kansas City, Mo.*
Gould, Gordon ..... *St. James, Mo.*
Hill, James Crane ..... *Carthage, Mo.*
Hurst, Henry William ..... *Kansas City, Mo.*
Imlay, John Logan ..... *Waukesha, Wis.*
Johnson, George F ..... *Tulsa, Okla.*
Kamp, Henry George ..... *St. Louis, Mo.*
Lawrence, Hiram Pettibone ..... *St. Louis, Mo.*
Lenox, Jennie Lynn ..... *Lake Springs, Mo.*
Mann, Walter Jay ..... *Canon City, Colo.*
Mesloh, Herbert George ..... *St. Louis, Mo.*
Moore, James John ..... *Springfield, Mo.*
Riddlesperger, Ralph Rudolphus ..... *Springfield, Mo.*
Rinehart, Volia Lendel ..... *St. James, Mo.*
Schumacher, Leon Burr ..... *St. Louis, Mo.*
Smart, Robert James ..... *St. Louis, Mo.*
Tao, Hung Tao ..... *Chaotung, Yunan, China.*
Triefenbach, George Louis ..... *St. Louis, Mo.*
Turner, Basil Harold ..... *St. Louis, Mo.*
Wong, Yen Charles ..... *Hunan, China.*

INDEX

	Page
Admission by Certificate	23
Admission by Examination	23
Admission as Special Student	24
Advanced Standing	24
Alumni Association	138
Athletic Association	136
Buildings and Grounds	19
Bureau of Geology and Mines	146
Calendar	4
Curricula	33
Degrees	37
Department of Chemistry	53
Civil Engineering	67
English and Modern Languages	76
Geology and Mineralogy	81
Mathematics	89
Mechanical Engineering	95
Metallurgy and Ore Dressing	104
Mining	119
Physics	126
Physical Training	132
Endowment	15
Excursions	133
Expenses	140
Experiment Station	145
Faculty	7
Fees	142
Finances	15
Fraternities	135
Jackling Loan Fund	144
Library	22
Mining Association	135
Student Council	136
Student Publications	137
Students	152
Theses	39
Y. M. C. A	135

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